1051-H-11

Y 3.N88:2 D / 3968

NUREG/CR-3968
PNL-5648
BHARC-400/85/017

163

Study of Operating Procedures in Nuclear Power Plants: Practices and Problems

ORIGINAL

Prepared by M. H. Morgenstern, V. E. Barnes, M. V. McGuire, L. R. Radford, W. A. Wheeler

Battelle Human Affairs Research Centers

Pacific Northwest Laboratory

Prepared for
U.S. Nuclear Regulatory Commission

BEST COPY AVAILABLE

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability of responsibility for any third party's use, or the results of such use, of any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

NOTICE

Availability of Reference Materials Cited in NRC Publications

Most documents cited in NRC publications will be available from one of the following sources:

1. The NRC Public Document Room, 1717 H Street, N.W.
   Washington, DC 20555
2. The Superintendent of Documents, U.S. Government Printing Office, Post Office Box 37082,
   Washington, DC 20013-7082
3. The National Technical Information Service, Springfield, VA 22161

Although the listing that follows represents the majority of documents cited in NRC publications, it is not intended to be exhaustive.

Referenced documents available for inspection and copying for a fee from the NRC Public Document Room include NRC correspondence and internal NRC memoranda; NRC Office of Inspection and Enforcement bulletins, circulars, information notices, inspection and investigation notices; Licensee Event Reports; vendor reports and correspondence; Commission papers; and applicant and licensee documents and correspondence.

The following documents in the NUREG series are available for purchase from the GPO Sales Program: formal NRC staff and contractor reports, NRC sponsored conference proceedings, and NRC booklets and brochures. Also available are Regulatory Guides, NRC regulations in the *Code of Federal Regulations*, and *Nuclear Regulatory Commission Issuances*.

Documents available from the National Technical Information Service include NUREG-series reports and technical reports prepared by other federal agencies and reports prepared by the Atomic Energy Commission, forerunner agency to the Nuclear Regulatory Commission.

Documents available from public and special technical libraries include all open literature items, such as books, journal and periodical articles, and transactions. *Federal Register* notices, federal and state legislation, and congressional reports can usually be obtained from these libraries.

Documents such as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings are available for purchase from the organization sponsoring the publication cited.

Single copies of NRC draft reports are available free, to the extent of supply, upon written request to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at the NRC Library, 7920 Norfolk Avenue, Bethesda, Maryland, and are available there for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

BEST COPY AVAILABLE

NUREG/CR-3968
PNL-5648
BHARC-400/85/017

Study of Operating Procedures in Nuclear Power Plants: Practices and Problems

Manuscript Completed: November 1986
Date Published: February 1987

Prepared by
M. H. Morgenstern V. E. Barnes, M. V. McGuire,
L. R. Radford, W. A. Wheeler

Battelle Human Affairs Research Centers
Seattle, WA 98105

Under Contract to:
Pacific Northwest Laboratory
Richland, WA 99352

Prepared for
Division of Human Factors Technology
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555
NRC FIN B2360

BEST COPY AVAILABLE

I

BLANK PAGE

ABSTRACT

This report describes the project activities, findings, and recommendations of a project entitled "Program Plan for Assessing and Upgrading Operating Procedures for Nuclear Power Plants." The project was performed by the Pacific Northwest Laboratory and Battelle Human Affairs Research Centers for the Division of Human Factors Technology, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (NRC).

The project team analyzed and evaluated samples of normal and abnormal operating procedures from 31 commercial nuclear power plant sites operating in the United States. The project team also visited nine nuclear power plants in the United States to obtain information on the development, use, and control of operating procedures. A peer review group was convened to advise the project team on the conduct of the project and to review and comment on the project report.

The report contains findings on the usability of operating procedures and on practices concerning the development, use, and control of operating procedures in nuclear power plants. The report includes recommendations to the NRC on the need to upgrade the quality of operating procedures. The report also discusses an approach to a program plan to assess and upgrade operating procedures.

BEST COPY AVAILABLE

BLANK PAGE

EXECUTIVE SUMMARY

The purpose of this report is to present the findings and recommendations from the project entitled "Program Plan for Assessing and Upgrading Operating Procedures for Nuclear Power Plants" of the Safety Technology Program. The TMI Action Plan Item I.C.9, "Long-Term Program for Upgrading of Procedures" required the U.S. Nuclear Regulatory Commission (NRC) to develop a program for upgrading plant operating procedures. The project described in this report is one of several projects designed to provide information and recommendations to the NRC on means of upgrading the quality of procedures used in nuclear power plants. For purposes of this report, normal procedures include normal operating procedures, off-normal procedures (called "special procedures" or "abnormal procedures" at some plants), and other procedures used by control room operators on a routine basis during non-emergency plant conditions. It is a basic assumption of this report that problems associated with these procedures can lead to operator error and thereby possibly jeopardize public health and safety.

This project involved two key information-collection and analytic efforts: (1) samples of operating procedures from 31 nuclear power plant sites were collected, reviewed, and evaluated; and (2) site visits were conducted to nine operating nuclear power plants throughout the United States. The results of these efforts are the major focus of this report.

In addition, the project involved four other activities: project scoping and definition; review of existing data bases and literature; preparation of a report on problems and issues associated with interfaces among different types of operating procedures (normal, abnormal, and emergency); and selecting and convening a peer review group to provide expertise and guidance concerning project activities and findings.

The major project findings were as follows:

Usability of Procedures

Operating procedures, considered as a group, fell below the rating "minimally acceptable" with regard to procedure usability.

Specificity of Procedures

Operating procedures are often written in vague terms and lack specificity. They often fail to describe the specific actions to be taken by operators in a step-by-step manner, to provide clear indicators of when a particular objective has been achieved, and to indicate when the procedure has been completed and should be exited. As a result, the procedures do not provide operators with the type of specific information they need to perform their tasks correctly. This lack of specificity particularly decreases the usability of the procedures for inexperienced operators.

BEST COPY AVAILABLE

Human Factors Considerations

Operating procedures typically do not conform to accepted human factors principles for high-quality procedures. The procedures often lack useful checklists, placekeeping aids, and other tools to enhance the ease and accuracy with which a procedure can be used.

Number of Procedures and Level of Detail Contained in Procedures

Plant staff interviewed during each site visit stated their belief that NRC requirements are resulting in "over-proceduralization." That is, the number of procedures at plants is so large as to be unmanageable, and many of the procedures contain inappropriate, excessive detail. However, it appears that in some situations, plants are writing procedures as the least costly and time-consuming way of responding to an NRC request for corrective action to a problem.

Plant Review of Procedures

Many of the plants visited have a system for reviewing new and revised procedures that results in long delays in formal procedure changes. The large number of changes to be reviewed can result in months of delay or, at the other extreme, a cursory approval of changes by plant review committees without the necessary technical evaluation where it is needed. Delays also can occur between the time a change (or new procedure) becomes effective and the point at which all operations personnel are informed of and/or trained on the new instructions. At a number of sites, this situation has led to the widespread use of temporary changes that, in some cases, receive minimal review.

Training and Operating Procedures

There appears to be little coordination between the training department and the individuals responsible for writing or revising operating procedures at many of the plants visited. One result is that problems with procedures that are identified during training often are not communicated to procedures preparers, with the consequence that the procedures are not revised to correct the observed problems.

Verification and Validation of Procedures

Only one plant required control room walk-throughs to assure that new or changed procedures concerning safety systems are usable. More often, walk-throughs, simulators, or other review techniques are used at the discretion of procedure preparation, operations, and training groups.

BEST COPY AVAILABLE

Based upon these findings and the results of other project activities, the following recommendations were offered:

Recommendation #1

It is recommended that the NRC, working with the industry, develop an explict set of criteria for identifying those tasks at each plant that should be performed with the assistance of a procedure. Although Part V of 10 CFR 50, Appendix B, provides some information regarding which activities should be prescribed by procedures (i.e., "activities affecting quality"), this requirement is vague and may be difficult for plants to interpret. The criteria that we are recommending be developed should more specifically describe the conditions under which procedures are necessary. These criteria, of course, would have to be related to the protection of public health and safety and should reflect what is known about when and how procedures can enhance safe operations. For example, borrowing from the rationale for requiring practice on specific tasks, we could state that procedures should be written and used for tasks that are complex, infrequently performed, and critical to safety (Cream, Eggemeier, and Klein, 1978).

It is the project team's belief that the problem of too many procedures may be rooted in the apparent absence of criteria for when a procedure is needed. The presence of a rationale for determining which procedures are needed may lead to an end to the current practice of writing procedures as an easy means of resolving issues identified by the NRC.

Recommendation #2

The NRC should develop further guidance on plant personnel use of operating procedures. That is, the NRC should evaluate the desirability of requiring verbatim compliance with NOPs and AOPs and, if it is found to be necessary, should take appropriate steps to ensure that such a policy is followed at plants.

Recommendation #3

It is recommended that the NRC and the industry determine when a high-level safety review, such as those conducted by plant review committees, is required. The findings of this and other studies indicate that the existing review process of procedures is overburdened and consequently unable to adequately address safety concerns. In some cases, committee review is entirely appropriate because of the safety-related nature of the procedure change. In other cases, committee review is probably not needed. Clear criteria for what kind of review is needed for what kind of change would help to speed the review process and would help to ensure that correct, usable procedures are available to the operator as soon as possible.

BEST COPY AVAILABLE

Recommendation #4

The final recommendation is that the NRC should require utilities to upgrade the quality of operating procedures identified by the process discussed in Recommendation #1. The requirements for programmatic development or upgrading of operating procedures should follow closely the programmatic requirements for the development of EOPs (see NUREG-0899), as is discussed in Section 5.0 of the report. That is, the program should include the following elements:

- Use of updated technical documentation to serve as the technical basis for the operating procedures.
- Use of a writers' guide for specifying format and content of the operating procedures.
- A verification program for ensuring that the procedures are written or upgraded using the correct technical information and following the guidance in the writers' guide.
- A validation program for ensuring that the procedure can be used by the operator, as intended, and, if used, would guide the operator's actions to produce the desired operating outcome.
- A training program, as needed, to train the operators in the correct use of the procedures.
- To ensure that procedure development and revision benefit from the experience of training personnel, it is also recommended that the NRC require plants to develop an administrative mechanism to enable the integration of training experience with procedure development.

To implement these recommendations, a program plan for upgrading operating procedures was proposed. The plan suggested that a Working Group comprised of NRC and industry representatives be formed (1) to review known information about developing, using, and controlling operating procedures; (2) to address the issues raised by the recommendations of this report; and (3) to develop an operating procedures upgrade program similar to the current NRC program to upgrade emergency operating procedures. The characteristics and advantages of such an approach are also discussed.

BEST COPY AVAILABLE

ACKNOWLEDGMENTS

We gratefully acknowledge the time, efforts, and assistance of the management and staff at the nuclear power plants who hosted our site visits and provided copies of operating procedures for review. In addition, we appreciate the contributions of our project technical monitor at the U.S. Nuclear Regulatory Commission, Dr. Michael J. Goodman. Mr. Leo J. Defferding of the Pacific Northwest Laboratory and the members of our peer review group offered valuable guidance and input to the project. Mrs. Charleen Sager provided much appreciated support and assistance throughout the project and in producing this report.

BEST COPY AVAILABLE

BLANK PAGE

TABLE OF CONTENTS

	Page
ABSTRACT	iii
EXECUTIVE SUMMARY	v
ACKNOWLEDGMENTS	ix
1.0 INTRODUCTION	1
1.1 Purpose of the Report	1
1.2 Project Overview	1
1.2.1 Project Task 1: Review of Existing Databases and Literature	2
1.2.2 Project Task 2: Project Scope	2
1.2.3 Project Task 3: Interface Issues	4
1.2.4 Project Task 4: Covening a Peer Review Group	4
1.3 Organization of This Report	5
2.0 REVIEW AND EVALUATION OF OPERATING PROCEDURES	7
2.1 Development of the Procedure Rating Form	7
2.2 Collection of Operating Procedures	8
2.3 Review and Evaluation Methodology	9
2.4 The Sample	9
2.5 Results of the Procedure Evaluation	10
2.5.1 General Results: Overall Ratings of Procedures	11
2.5.2 Specific Results: Ratings of Procedure Format	11
2.5.3 Specific Results: Ratings of Procedure Content and Style	13
2.6 General Observations	14
2.7 Summary of Findings	16
3.0 SITE VISITS	19
3.1 The Site Visit Protocol	20
3.2 Plant Personnel Interviewed	20
3.3 Site Visit Findings	21
3.3.1 Reasons for Changing Existing Procedures or Writing New Ones	21
3.3.2 Procedure Preparation	23
3.3.3 Verification and Validation of Procedures	26
3.3.4 The Procedure Review Process	27
3.3.5 Distribution and Control of Procedures	30

BEST COPY AVAILABLE

Page

3.3.6 Policies on Use of Procedures 30
3.3.7 Procedures and Training 31

3.4 Summary of Findings 32

4.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 37

4.1 Summary 37

4.1.1 Findings from the Review and Evaluation of Procedures 37
4.1.2 Findings from the Site Visits 37

4.2 Conclusions 38
4.3 Recommendations 40

4.3.1 Recommendation #1 40
4.3.2 Recommendation #2 41
4.3.3 Recommendation #3 41
4.3.4 Recommendation #4 41

5.0 PROGRAM PLAN 43

5.1 Consolidate Known Information 43
5.2 Convene NRC Operating Procedures Working Group 43
5.3 Answer Questions Posed in the Recommendations 43
5.4 Develop Operating Procedures Upgrade Program Requirements 43
5.5 Time Line for NRC Program 46

6.0 REFERENCES 47

APPENDICES

A. Letter Report on Results of Review of Existing Data Bases . . . . . A-i

B. Letter Report on Results of Project Scoping Efforts . . . . . B-i

C. Letter Report on Results of Preliminary Assessment of Interface Problems . . . . . C-i

D. Overview of the Peer Review Group Meetings and Peer Review Group Membership . . . . . D-i

E. Procedure Review and Evaluation Methodology and Results . . . . . E-i

F. Site Visit Methodology and Protocol . . . . . F-i

BEST COPY AVAILABLE

LIST OF FIGURES

Figure		Page
2.1	Average, Minimum, and Maximum Number of Pages for Each Procedure	12
2.2	Average and Maximum Number of Revisions for Each Procedure	12

BEST COPY AVAILABLE

BLANK PAGE

LIST OF TABLES

Table		Page
2.1	Site Response Rate by NRC Region	9
2.2	Number and Type of Procedures Obtained from Plants of Different Reactor Types	10
2.3	Percentage of Procedures Reviewed that Contain Format Characteristics	14
2.4	Percentage of Procedures Reviewed that Contain Content Characteristics	15
3.1	Summary of Sites Visited	19
3.2	Job Titles of Plant Personnel Interviewed During Site Visits	20
3.3	Reasons for Procedure Development or Revision at the Sites Visited	22
3.4	Procedure Preparation Practices at Sites Visited	24
3.5	Methods of Verification and Validation at Sites Visited	26
3.6	Individuals/Groups that Review Procedures at Sites Visited	28
3.7	Summary of Site Visit Findings	33

BEST COPY AVAILABLE

1.0 INTRODUCTION

The TMI Action Plan Item I.C.9, "Long-Term Plan for Upgrading of Procedures" required the Nuclear Regulatory Commission (NRC) to undertake a course of action to improve the quality of plant procedures (NUREG-0660). The project described in this report is one of several projects designed to provide information and recommendations to the NRC on the status of procedures used in the industry and on means of upgrading the quality of procedures used in nuclear power plants, including operating procedures. For purposes of this report, operating procedures include normal operating procedures (NOPs), off-normal procedures (referred to as abnormal operating procedures [AOPs] in this report) and other procedures used by control room operators on a routine basis during non-emergency plant conditions.

The significance of these procedures lies in their potential either to prevent or to encourage operator error and, consequently, to affect public health and safety. Procedure-related operator error has been identified as playing a significant role in the event at Three Mile Island. Other investigations of nuclear power plant operations also have noted the relationship between human error and such procedural problems as poor organization, incomprehensability, and other types of usability deficiencies (NUREG/CR-0153). Problems with procedures have led to events with the potential to affect adversely public health and safety (e.g., Salem event in 1984) and have been linked to the potential for damage to expensive plant equipment as well as breech of containment (NUREG/CR-2837; PNL-4327). Consequently, it is a basic assumption of this report that problems associated with operating procedures can lead to operator error and thereby potentially jeopardize public health and safety.

1.1 Purpose of the Report

The purpose of this report is to present the findings and recommendations from the project entitled "Program Plan for Assessing and Upgrading Operating Procedures for Nuclear Power Plants." In addition, a program plan for implementing the recommendations is described in the report.

1.2 Project Overview

The project involved several major data collection and analytic efforts. First, an extensive project scoping task was undertaken. Existing databases were reviewed and analyzed to assess what types of procedures played a role in safety related incidents in the nuclear industry. A computerized literature search was used to access pertinent reports regarding the development, use, and control of procedures. In addition, individuals with expertise in procedure development, use, and control in the nuclear industry were interviewed about their major concerns regarding operating procedures.

Concurrent with the scoping activities, an evaluation form was developed to rate the usability of a sample of operating procedures that were

BEST COPY AVAILABLE

collected from 31 nuclear sites. In addition, an interview protocol was developed for use on site visits to nine operating plants in order to review plant practices concerning the development, use, and control of operating procedures.

The sample of plant procedures was obtained by contacting 83 operating nuclear power plants and requesting procedures for six separate plant operations. Thirty-one sites responded to the request. The plant site visits were conducted to capture a range of operating experience in commercial nuclear power production. Thus, NRC region, plant size, and plant type were considered in the selection of sites.

In addition to these two key project tasks, the following tasks also were carried out: (1) preparation of a preliminary report on problems and issues associated with interfaces within and between different types of operating procedures (NOPs, AOPs, and emergency operating procedures [EOPs]); and (2) selection and use of a peer review group to provide expertise and guidance concerning project activities. These two tasks and the project activities preparatory to the site visits are discussed briefly below.

1.2.1 Project Task 1: Review of Existing Databases and Literature

The first project task involved the identification and review of existing studies and related data on nuclear power plant operating procedures. This task involved three lines of inquiry:

1. Identification of government-sponsored and other research related to nuclear power plant procedures. To this end, computerized literature searches of five databases were conducted: National Technical Information Service (NTIS); DOE (energy file); COMPENDEX; Engineering Index; and Defense Research On Line System (DROLS).

2. Review of current practices and standards for nuclear power plant operating procedures including ANS/ANSI standards and NRC Regulatory Guides.

3. Identification of procedure-related problems through analysis of Licensee Event Reports and the NRC 0766 Data Processing System of Inspection and Enforcement reports.

The results of these inquiries were summarized and reported to the NRC in a letter report (see Appendix A).

1.2.2 Project Task 2: Project Scope

The second project task involved determining the project scope, i.e., identifying the procedures that should be classified as operating procedures for purposes of this project. This activity was an extension

BEST COPY AVAILABLE

of the first project task. Consequently, the results of the Task 1 letter report were used in the final scoping effort.

The determination of what types of procedures should be addressed by the project was complicated by the large number of procedures that can be classified as operating procedures; operating procedures can refer to all plant procedures except maintenance procedures. Evaluating this broad a range of procedures is impractical and unnecessary, however, because many operating procedures do not involve plant activities related to public health and safety and consequently fall outside areas of NRC responsibility. Therefore, the objective of this task was to identify a smaller set of operating procedures to study.

Because one goal of the project was to identify operating procedures that have direct safety implications, the first line of inquiry was directed at records of safety problems in nuclear power plants found in the Nuclear Safety Information Center database, which contains LER data and the NRC 0766 Data Processing System. Second, operator license examiners and trainers at the Federal Training Center were interviewed to identify procedural areas that they find pose the greatest difficulties for operators and are most likely to lead to operator errors with safety implications. Third, a sample of publically-available INPO evaluations that were conducted in 1981 were examined to determine the procedures problems and industry practices identified by the INPO evaluators. An extensive discussion of the information gleaned from these sources was presented in a letter report to the NRC (see Appendix B).

Based on the evaluation of the information obtained from these sources, the following three conclusions were reached concerning project scope:

1. The content and format of NOPs, AOPs, and surveillance procedures should be evaluated, including how these procedures guide transitions to other procedures. This evaluation should also consider other usability characteristics of the procedures.

2. Administrative policies concerning the development, use, revision, and control of operating procedures and the training of operations personnel to use procedures should be evaluated.

3. Industry practices concerning the ways in which operating instructions and information are made available to operators (e.g., job performance aids [JPAs] such as placards, labels, and indexing techniques) should be assessed.

These conclusions also were submitted to the NRC in the Task 2 letter report. The NRC concurred with the conclusions with one exception. The NRC decided that surveillance procedures would be addressed by the NRC Maintenance and Surveillance Program and, therefore, would not be addressed by the project for reviewing and upgrading operating procedures.

BEST COPY AVAILABLE

1.2.3 Project Task 3: Interface Issues

The third project task looked at a specific concern: interfaces within and between normal, abnormal, and emergency operating procedures. "Procedure interface" refers to how the procedure informs operators that they should move from one procedure to another or to another section of the same procedure. Information related to the interface issue was gathered during the site visits, the project scoping, and the review of existing databases and literature. This information was synthesized and presented in a letter report to the NRC (see Appendix C). Conclusions and findings from a number of related projects on procedures and safety system status verification were incorporated into the letter report on interface problems. The results of this effort have been used to initiate a separate project further exploring interfaces within and between different types of procedures.

1.2.4 Project Task 4: Convening a Peer Review Group

A peer review group was established to advise the project team on matters related to the conduct of the project and to review reports written during the project. The individuals participating in the peer review group were selected on the basis of their experience and background regarding (1) procedure development, (2) the operational use of procedures, (3) interfaces among operating procedures, and (4) the numerous areas of plant operations that require procedures.

The peer review group consisted of six members: two staff from commercial nuclear power plants; one person responsible for developing operating procedures for a defense nuclear reactor; one person with experience in nuclear operations and the use of operating procedures, who currently works for a major aircraft manufacturing firm; one person working for a nuclear industry engineering and operations consulting firm; and a human factors engineer with extensive experience in the cognitive aspects of procedure use and development.

Two peer review group meetings were held during the course of this project. Overviews of the meetings are provided in Appendix D. During the meetings, review group members provided input concerning planned project tasks and interpretation of project findings. Additionally, members reviewed project reports (including this report), and their comments and suggestions were incorporated into final versions of the reports.

At the review group meetings, the individual opinion of each expert was sought, rather than a consensus opinion of the group. Review group members were brought together to permit the free flow of all available information that contributed to the formulation of individual expert opinions. Where appropriate, the project team has reported the team's perceptions of an average or consensus of the peer review review group members' individual opinions.

BEST COPY AVAILABLE

1.3 Organization of This Report

The remainder of the report is organized into four sections. Section 2.0 describes the review and usability evaluation of the sample of operating procedures collected from 31 nuclear sites. Section 3.0 presents the findings of the site visits to nine operating nuclear power plants. Section 4.0 presents an overview and discussion of project findings and outlines recommendations for NRC and industry actions to upgrade operating procedures. Finally, Section 5.0 presents a program plan for addressing the issues identified in the course of the project.

BEST COPY AVAILABLE

BLANK PAGE

2.0 REVIEW AND EVALUATION OF OPERATING PROCEDURES

A review and evaluation of a sample of NOPs and AOPs formed a key part of this project. The purpose of the review was to evaluate the usability of the procedures in terms of established good practices for communicating procedural information. This section of the report presents a brief summary of the method used to review and evaluate the operating procedures. Highlights of the results of the evaluation are also presented. More detailed descriptions of the methodology and the assessment findings are contained in Appendix E.

2.1 Development of the Procedure Rating Form

A procedure rating form and an evaluation methodology were developed to provide a means for evaluating the usability of procedures. Usability is defined as those characteristics of a procedure that enable operators to use the procedure to operate the plant in a safe manner with a minimum of errors. In operational terms, usability means that the procedures should provide guidance to the operator that is accurate, complete, readable, and convenient to use.

As noted above, the review and evaluation focused primarily on usability of the procedures in terms of established good practices for communicating procedural information. The review did not address the engineering- or hardware-related technical accuracy of the procedures. Accordingly, the review did not verify, for example, the accuracy of temperatures, pressures, or flow rates specified in the procedures. Rather, the review focused on whether information was presented in a clear and unambiguous manner.

The procedure rating form contained 34 items. The items addressed procedure format (e.g., procedure name and page numbers included on each page of the procedure); the style of presentation (e.g., units of measure consistent, instructions written in concise, identifiable steps); content (e.g., entry and exit conditions specified); and an overall rating of the procedure.

The items in the procedure rating form were selected and adapted from a number of sources. The primary source was Section 4.4, "Presentation of Information," of NUREG-0799, Draft Criteria for Preparation of Emergency Operating Procedures. The guidance in NUREG-0799 was based, in part, on NUREG/CR-1977, Guidelines for Preparing Emergency Procedures for Nuclear Power Plants. The sources for the criteria used in developing the guidelines in NUREG/CR-1977 were adapted for use in commercial nuclear power plants and included:

- Department of Defense military specifications and standards
- Air Force Human Resources Laboratory and the Navy Personnel Research and Development Center research
- NASA guidelines for launch operations procedures

BEST COPY AVAILABLE

- Air Transport Association (ATA) guidelines for procedures used internationally by the airlines.

Additionally, several procedure writers' guides and checklists currently used at nuclear plants, including an INPO writers' guide, were used in developing the procedure rating form. The operating procedures rating form is included in Appendix E.

2.2 Collection of Operating Procedures

Three criteria were identified and used to select procedures for review. These are:

- The procedures would be common to both boiling water reactors (BWRs) and pressurized water reactors (PWRs).
- The sample of procedures would include both NOPs and AOPs.
- The procedures would be representative of all plant operating procedures in terms of complexity and the frequency of use.

Using these criteria, the following six procedures were selected by the peer review group and the project staff for review and analysis:

- Normal Operating Procedures
  - Plant start-up (cold shut down) to 15% power
  - Start-up of the condensate and feedwater system
  - Reactivity balance (calculation)
  - Reactor coolant leak rate (calculation).
- Abnormal Operating Procedures
  - Loss of condenser vacuum
  - Loss of component cooling.

Letters were sent to all commercial nuclear power plants with current operating licenses (83 plants at 56 sites) asking them to provide voluntarily the six procedures for review. In the case of multi-unit sites where all plants used basically the same procedures, only one set of procedures was sought for review. Plants were informed that their procedures would be evaluated without the reviewers knowing from which plant each procedure came and that reports of the results of the evaluations would not identify individual plants. A copy of the letter sent to the plants also is included in Appendix E.

BEST COPY AVAILABLE

2.3 Review and Evaluation Methodology

Five project team members participated in the evaluation of procedures. These project team members had prior experience in drafting procedure preparation guidelines; reviewing nuclear plant maintenance procedures, EOPs, or NOPs; and/or developing the procedure rating form for this project.

The reviewers first pretested the rating form and evaluation methods by reviewing independently the same sample of three procedures. The pretest indicated a high level of consistency among the ratings provided by each reviewer. Some minor modifications were made to the rating form as a result of the pretest. All of the procedures from a particular plant were reviewed by the same reviewer, but procedures from each plant were reviewed by only one reviewer. Therefore, inter-rater reliabilities were not calculated for the total sample.

2.4 The Sample

Fifty-six sites representing 83 commercially operating nuclear power plants were asked to provide six procedures for review. Thirty-one sites (representing 46 plants) responded to this request, for a response rate of 55% (see Table 2.1). The highest response rate was from sites in NRC Region 4 (100%). The other four NRC regions had moderate response rates: 44% to 60% of the sites in these regions provided copies of procedures for review. Regions 4 and 5 comprise a smaller portion of the sample (13% and 6% of the sites, respectively) compared to the other regions, because Regions 4 and 5 have fewer operating nuclear plants. The sample also represented the mix of plant technologies currently found in the U.S.: 10 of the sites had BWRs, 20 of the sites had PWRs, and 1 site had a helium-cooled plant.

Table 2.1. Site Response Rate by NRC Region

NRC Region	Number of Sites with at Least one Operating Unit	Number of Sites Providing Procedures for Review	Response Rate by Region
1	18	8	44.4%
2	15	9	60.0
3	15	8	53.3
4	4	4	100.0
5	4	2	50.0
Total	56	31	55.4%

BEST COPY AVAILABLE

A total of 154 procedures were received and assessed--49 from BWRs, 101 from PWRs, and 4 from the helium-cooled plant (see Table 2.2). This total included 103 NOPs (45 of which concerned calculations) and 51 AOPs. Most plants sent all six of the procedures requested, but BWR sites sent fewer calculation procedures. Comments received from some BWR sites suggest that this may be due to different nomenclature and resulting confusion over definitions of the calculation procedures. Whatever the cause, however, there is no reason to believe that the reduced numbers of BWR calculation procedures adversely affects the results of our reviews. All of the following results are presented for all plant types combined.

Table 2.2. Number and Type of Procedures Obtained from Plants of Different Reactor Types

	Plant Type			
Procedure Type	BWR	PWR	Other	Total
Normal:				
Start-up	10	18	1	29
Condensate and Feedwater Start-up	9	19	1	29
Normal-Calculation:				
Reactivity Balance	5	15	1	21
Reactor Coolant Leak	6	17	1	24
Abnormal:				
Loss of Condenser Vacuum	9	14	0	23
Loss of Component Cooling	10	18	0	28
Total	49	101	4	154

2.5 Results of the Procedure Evaluation

The purpose of this section is to present the general and specific results of the procedure evaluation in the following order:

- General Results: Overall Ratings of Procedures (Section 2.5.1)

BEST COPY AVAILABLE

- Specific Results: Ratings of Procedure Format (Section 2.5.2)
- Specific Results: Content and Style (Section 2.5.3).

Appendix E details the responses to each item on the procedure rating form and presents the results of several statistical tests that were applied to the ratings.

2.5.1 General Results: Overall Ratings of Procedures

In addition to providing specific ratings on 33 features of each procedure, reviewers rated the procedures for general acceptability on the following five-point scale:

5 = Very good

4 = Good

3 = Minimally acceptable

2 = Poor

1 = Very poor.

The average of these general, overall ratings for all plants was 2.6. This average indicates that, in the ratings of the reviewers, the average procedure was somewhere between "poor" and "minimally acceptable."

The three different types of procedures (i.e., normal, normal-calculation, and abnormal) differed considerably in the number of pages in the procedure (see Figure 2.1) and the number of times that it had been revised (see Figure 2.2). The more detailed start-up procedures had the largest number of pages and revisions, followed by the calculation procedures, and then the abnormal procedures.

2.5.2 Specific Results: Ratings of Procedure Format

The first ten items on the procedure rating form address procedure format. These items pertain to administrative details that assist in the use of the procedure or that help eliminate common errors in the way that procedures are used. These administrative details are:

- A table of contents
- A clear statement of objectives
- Consistency of format throughout the procedure
- Indications that the procedure has gone through a review and approval process
- Labeling of each page with the name of the procedure

BEST COPY AVAILABLE

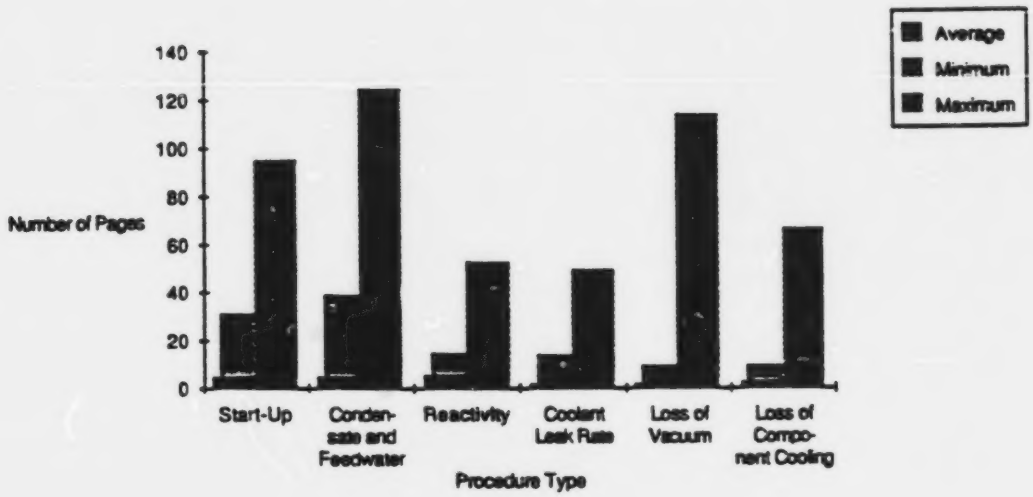

Figure 2.1. Average, Minimum and Maximum Number of Pages for Each Procedure

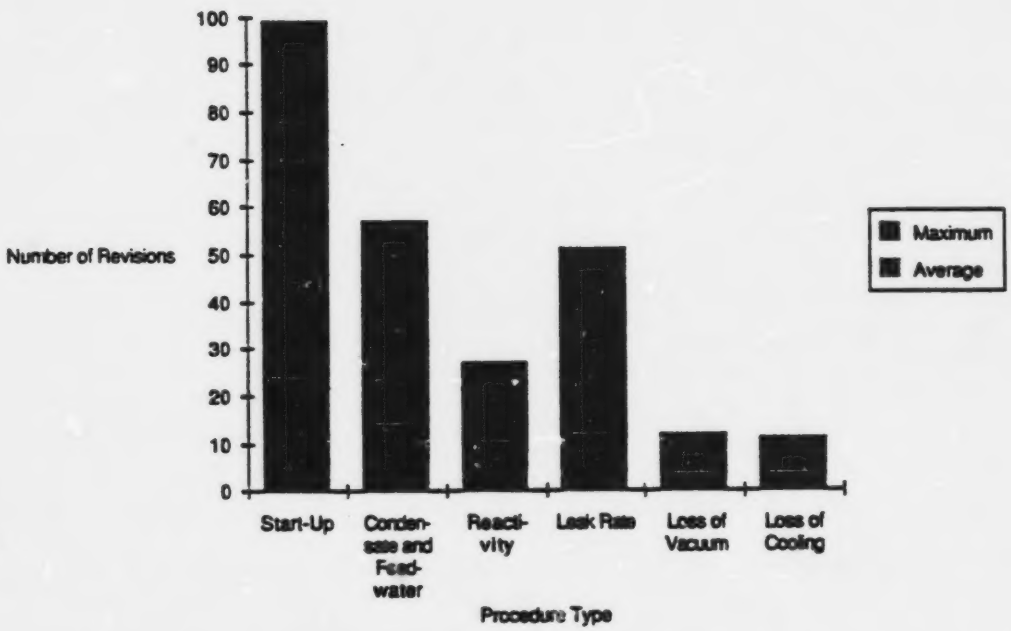

Figure 2.2. Average and Maximum Number of Revisions for Each Procedure

BEST COPY AVAILABLE

- Labeling of each page with the number of the procedure
- Labeling of each page witn the number of the latest revision
- Labeling of each page with the date of the procedure or the date of the latest revision
- Labeling of each page with the page number and the total number of pages (i.e., "Page __ of __") in the procedure
- Marking or highlighting the latest revision.

Table 2.3 is a summary of the percentage of procedures across all reactor types that contained these ten features. Of particular interest and concern is fact that few procedures (only 31%) highlighted the latest changes to a procedure. Given the fact that operators state that they use the procedure as a "memory jogger" rather than following tne procedure exactly, it is important that some means be used to draw their attention to important changes. Another important finding was that only 62% of the procedures had the total number of pages as part of the page numbering system. Given the common problem of losing the last part of stapled documents, this simple practice can eliminate much confusion.

2.5.3 Specific Results: Ratings of Procedure Content and Style

In addition to format-related administrative details, which improve the usefulness and usability of a procedure, ratings were made on several features related to procedural content that a good operating procedure should have. These include:

- Steps that express limits quantitatively rather than qualitatively
- Identifying controls, indicators, and/or equipment completely
- Procedures that are written for different skill levels
- Single indicators to tell the operator when the objective of the step has been accomplished
- Multiple indicators to tell the operator when the objective of the step has been accomplished
- Specifying entry conditions
- Specifying exit conditions
- Specifying subsequent actions
- References to the source of information associated with the background of the procedure
- References to the source of information associated with action steps.

BEST COPY AVAILABLE

Table 2.3. Percentage of Procedures Reviewed that Contain Format Characteristics

Format Characteristics	Procedure Type: Start-up	Condensate and Feedwater Start-up	Reactivity Balance	Reactor Coolant Leak Calculation	Loss of Condenser Vacuum	Loss of Component Cooling	Total of All Procedures
Table of Contents	32.4%	27.0%	5.4%	8.1%	8.1%	18.9%	24.0%
Statement of Objectives	93.1	75.9	76.2	83.3	52.2	42.9	70.8
Consistency of Format	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sign Offs/Approvals	86.2	82.8	85.7	79.2	73.9	82.1	81.8
Procedure Name on Every Page	24.1	20.7	14.3	8.3	30.4	17.9	19.5
Procedure Number on Every Page	100.0	100.0	100.0	100.0	100.0	96.4	99.4
Revision Number on Every Page	72.4	72.4	71.4	62.5	65.2	64.3	68.2
Revision Date on Every Page	51.7	37.9	28.6	29.2	47.8	46.4	40.9
"Page --- of ---"	62.1	65.5	61.9	54.2	69.6	60.7	62.3
Revisions Marked	31.0	27.6	28.6	37.5	30.4	28.6	30.5

Table 2.4 summarizes the results of these content-related indicators of procedure usefulness. Of particular interest in these findings is the fact that only 70% of the procedures told the operator what to look for to know when the objectives of a step had been accomplished (single indicators of achieved objectives), and only 34% provided multiple indicators (e.g., ammeter and flow meter to determine a pump was running) that the objectives of a step had been achieved.

2.6 General Observations

In reviewing and evaluating the 154 procedures provided by operating plants, reviewers came to a consensus concerning several aspects of the

BEST COPY AVAILABLE

Table 2.4. Percentage of Procedures Reviewed that Contain Content Characteristics

Content Characteristics	Procedure Type: Start-up	Condensate and Feedwater Start-up	Reactivity Balance	Reactor Coolant Leak Calculation	Loss of Condenser Vacuum	Loss of Component Cooling	Total of All Procedures
Limits Stated Quantitatively	96.6%	82.8%	90.5%	79.2%	78.3%	64.3%	81.8%
Controls Identified Completely	93.1	100.0	66.7	87.5	73.9	92.9	87.0
Procedures Written for Different Skill Levels	10.3	6.9	4.8	4.2	4.3	7.1	6.5
Single Indicators	96.6	86.2	47.6	70.8	47.8	60.7	70.1
Multiple Indicators	37.9	31.0	33.3	37.5	30.4	32.1	33.8
Entry Conditions Specified	100.0	93.1	85.7	91.7	95.7	100.0	94.8
Exit Conditions Specified	82.8	72.4	66.7	83.3	78.3	78.6	77.3
Subsequent Actions Specified	75.9	48.3	76.2	82.6	78.3	67.9	70.6
Refers to Source of Information	62.1	62.1	66.7	79.2	21.7	14.3	50.6
Refers to Source for Action Steps	58.6	34.5	47.6	33.3	17.4	25.0	36.4

procedures. These are included here as observations, rather than conclusions.

First, although the quality of the procedures did not seem to depend upon the type of procedure being reviewed (i.e., normal, normal-calculation, or abnormal), the different types of procedures were written differently. Procedure writers appeared to have adopted different approaches in writing the different types of procedures and many procedures of the same type appeared to have been written by different individuals. In general, the NOPs reviewed were more descriptive and typically included more narrative than the others. The AOPs were most succinct and took a more directive approach.

BEST COPY AVAILABLE

Second, the procedures typically violated accepted human factors principles concerning the optimal format, style, and content of operating procedures. This observation was supported by the specific conclusions concerning the ratings of procedures, discussed above. Finally, the fact that procedures were often written in vague terms and typically lacked much specificity suggests that the procedures require operators to rely heavily upon their knowledge, training, experience, and judgment in order to use both NOPs and AOPs effectively.

2.7 Summary of Findings

The review and evaluation of the selected operating procedures yielded the following findings:

- The procedures were judged overall to be below the level of "minimally acceptable."

- The majority of the procedures reviewed provided operators with some assistance in using the procedure, such as page numbers (62%), consistent formats (100%), and the presence of sign-offs/approvals on the procedure (82%). However, three features that could greatly facilitate procedure use were present in fewer than one-third of the procedures: only 30.5% of the procedures marked or in some way indicated the most recent revisions to the procedure; 24% included a table of contents; and 19.5% included the procedure name on each page of the procedure.

- The majority of procedures reviewed included several features related to the content or style of the procedure that would be expected in high quality procedures. These features included stating limits in quantitative terms (82%), completely identifying controls and equipment (87%), and specifying entry (95%) and exit (77%) conditions. However, a sizeable minority of procedures failed to include such features. Thirty percent failed to specify subsequent or follow-on actions to the procedure and excluded single (and multiple) indicators signalling that the objective of the procedure step had been achieved.

- Procedures frequently did not include operator aids such as checklists, placekeeping aids, graphs, and figures. Also, very few procedures were written for different skill levels (i.e., experienced operators and newly licensed operators).

- Procedures in general were written in vague terms and lacked specificity. First, procedures often did not describe specific actions to be taken by operators in step-by-step form. Second, procedures often failed to specify indicators or benchmarks showing that the objective of a procedure (or step within a procedure) had been achieved. Third, procedures frequently lacked details

BEST COPY AVAILABLE

specifying when the procedure is completed, or how and when the procedure should be exited.

Conclusions and recommendations based on these findings are presented in Section 4.0.

BEST COPY AVAILABLE

BLANK PAGE

3.0 SITE VISITS

The purpose of the site visits was to identify current practices and problems with operating procedures in the nuclear power industry. Personnel at nine nuclear power plants were interviewed by project team members during site visits. The interviews gathered information about the preparation, use, and control of operating procedures and about any procedure-related problems experienced at the sites. Table 3.1 shows the characteristics of the nine sites visited.

Table 3.1. Summary of Sites Visited

	Description of Sites	Number of Sites
Type of Plant	BWR	1
	PWR	8
Number of Units	1	5
	2	3
	3	1
Years in Operation	2-4	2
	7-8	3
	10-11	3
	17	1
NSSS Vendor	Westinghouse	4
	General Electric	1
	Babcock & Wilcox	3
	Combustion Engineering	1
Architect-Engineer	Bechtel	3
	Fluor	1
	Stone & Webster	1
	United Engineers & Constructors	1
	Burns & Roe	1
	Gilbert	1
	Utility	1

BEST COPY AVAILABLE

In Sections 3.1 and 3.2, the site visit methods are highlighted. Sections 3.3 and 3.4 present site visit findings and conclusions. Appendix F contains a detailed discussion of the methods and rationale used to select sites and to set up and conduct the interviews.

3.1 The Site Visit Protocol

The site visit protocol was designed by project staff and the NRC project monitor, with input from the peer review group members. Because of the differences in the organizational and functional structures of the plants visited and the diverse organizational roles of the individuals interviewed, strict adherence to a set of highly defined questions and procedures was not possible. Instead, the site visit protocol was designed to be flexible and to permit follow-up on significant issues when interviewing plant personnel. The interview protocol is reproduced in Appendix F.

3.2 Plant Personnel Interviewed

Table 3.2 shows the job titles of the personnel interviewed at each plant. As shown in the table, the plant staff interviewed had one of three functions: (1) plant personnel directly involved in writing and/or using procedures, (2) operations supervisory personnel, and (3) training

Table 3.2. Job Titles of Plant Personnel Interviewed During Site Visits

Plant Personnel Interviewed	Site Number*								
	1	2	3	4	5	6	7	8	9
Procedure Preparers	X	X	X	X	X	X	X	X	X
Operators			X	X			X	X	X
Trainers	X		X	X		X			X
Document Control					X				
Shift Supervisors		X	X	X				X	
Operations Superintendent		X		X	X		X		
Plant Manager		X		X	X	X	X	X	

*Sites are not numbered consistently in the tables of this section to prevent inadvertent identification of the plants visited for this project.

BEST COPY AVAILABLE

staff. In addition, at five plants a control room walk-through was conducted to observe how procedures were used.

3.3 Site Visit Findings

Tne purpose of this section is to report on the information concerning procedure development, use, and control provided by personnel interviewed at nuclear power plants and the observations of the site visit teams. The section is organized as follows:

- Reasons for Changing Existing Procedures or Writing New Ones (Section 3.3.1)
- Procedure Preparation (Section 3.3.2)
- Verification and Validation of Procedures (Section 3.3.3)
- The Procedure Review Process (Section 3.3.4)
- Distribution and Control of Procedures (Section 3.3.5)
- Policies on Use of Procedures (Section 3.3.6)
- Procedures and Training (Section 3.3.7).

3.3.1 Reasons for Changing Existing Procedures or Writing New Ones

Because all of the plants visited had been operational for some time, the bulk of procedure development work has been completed. For the most part, initial procedure development efforts focused on start-up procedures and on NRC-required procedures for operating safety-related equipment.

Currently, new procedures are developed infrequently at the plants, although all of the plants are in the process of upgrading their emergency operating procedures (EOPs) in response to NRC Generic Letter 82-33 (NUREG-0737, Supplement 1). Most procedure development efforts are focused on revising existing procedures.

The reasons given for developing a new or revised procedure are identified in Table 3.3. These reasons fall into three broad categories:

- NRC requirements and guidance
- Plant modifications
- Plant experience.

In eight of the nine plants, the most frequently cited reasons for developing or revising procedures are: an NRC requirement, typically in the form of new regulations and guidance (e.g., NUREG-0799); audits by INPO; and Inspection and Enforcement (I&E) bulletins. NRC requirements and guidance were reported to be the most common reason for writing new

BEST COPY AVAILABLE

Table 3.3. Reasons for Procedure Development or Revision at the Sites Visited

Reasons for Procedure Development or Revision	Site Number								
	1	2	3	4	5	6	7	8	9
NRC mandate	X	X	X	X	X		X	X	X
INPO audits				X					X
Design or equipment change	X	X	X		X	X	X	X	X
Operator suggestions			X	X	X	X	X	X	
Biennial reviews				X			X		
Trainers' suggestions						X		X	
Event reports				X					X
Operator errors									X

procedures and the reason for the rapid increase in the number of new procedures and procedure revisions at the sites. Further, these NRC-required procedure changes are sometimes seen by plant personnel as inconsistent and unnecessary.

Interviewees at all nine plants report a belief that NRC activities related to procedures have increased both the number of operating procedures and the level of detail with which they are written. For example, personnel at one plant reported that operations began with a limited number of procedures that only addressed safety-related equipment. During the "full-term operating license" process, the NRC required extensive expansion of their plant procedures. Tne number of procedures of all types at this plant increased to approximately 1,700 with over 100 normal operating procedures. Both the number of procedures increased and the procedures became substantially more detailed. Another plant reported having approximately 6,000 procedures and processing roughly 100 procedure changes per month. A third plant requires 50 notebooks to contain a complete set of plant procedures. Plant personnel reported that this proliferation of procedures negatively affects plant operations by overburdening administrative systems to develop and control procedures. Inconsistent enforcement of regulations by NRC resident inspectors and auditors also was reported by interviewees at four sites as contributing to procedure proliferation. However, peer review group members indicated that the proliferation of procedures, at least at some

BEST COPY AVAILABLE

sites, is due, in part, to the fact that plants find that writing a new procedure is less costly and less time consuming than pursuing other alternatives in response to NRC requests for corrective action to a problem.

Tne second most frequently mentioned reason for developing or revising procedures is a design change or equipment modification. The majority of these changes occur during outages. Development of new or revised procedures is initiated following outages at seven of the nine plants. Two sites reported delays of six months to a year following outages before procedures were altered to reflect design changes. Consequently, equipment and systems were operated with incorrect procedures or without procedures for relatively long periods of time, a condition that affects procedure use (cf. Section 3.3.6, Policies on the Use of Procedures). In one case, an interviewee estimated that close to 90% of the procedures require revisions following an outage.

Operating experience constitutes a third source of procedure changes (i.e., incidents during operations, operator and trainer suggestions, event reports from other plants, operator error, and mandated periodic reviews). This source of procedure revisions, however, was identified by a minority of plant personnel interviewed.

3.3.2 Procedure Preparation

Two common characteristics of the procedure preparation process were observed at the plants visited. First, none of the plants conduct formal task analyses to guide procedure development. Vendor-supplied technical information and the procedure writer's knowledge about the task provide information about how the task is to be performed and the sequencing of activities. In several cases where personnel reported that task analyses are conducted for operator training programs, the results of the analyses have not been made available to procedure preparers.

The second characteristic of the procedure preparation process common to all plants was that plant procedures are prepared in-house using plant staff. Six plants had used consultants in the past to write procedures with varying degrees of satisfaction. The primary reason reported for dissatisfaction with consultants was that they wrote generic rather than plant-specific procedures. Generic procedures required extensive and costly rewrites to make them useful to operators. On the other hand, consultants were seen as useful in providing training to procedure writers or in providing guidance on how to organize and format procedures, the appropriate language and style, etc. None of the sites visited currently employ human factors specialists or technical writers to develop or revise procedures.

3.3.2.1 Who writes procedures?

Plant staff reported differences in the personnel or working groups assigned responsibility for preparing procedures (see Table 3.4) and in the approaches (i.e., use of writers' guides, dedicated staff) taken to

BEST COPY AVAILABLE

the procedures preparation task. Three plants have established a procedures group with responsibility for procedure preparation. At one plant, the group is comprised of staff (engineers and operators) who are permanently dedicated to preparing plant operating procedures. At another plant, the procedures group consists of two permanent staff members, both of whom are engineers and licensed senior reactor operators (SROs), and the members of each plant operations crew, who are temporarily assigned to the procedures group for a six-month period every two and a half years. At the third site (a multiple unit site), procedures are written by specialists at each unit and then reviewed by a site procedures group staffed by engineers and senior operations personnel. These specialists are experts in a particular plant system.

Table 3.4. Procedure Preparation Practices at Sites Visited

Plant Procedure Preparation Practices	Site Number								
	1	2	3	4	5	6	7	8	9
Use of Consultants	X	X	X			X		X	X
Dedicated Procedures Group		X	X						X
Written by Engineers		X				X	X	X	
Written by Operators	X	X		X	X		X	X	X
Use of Writers' Guides		X	X						

At three sites, primary responsibility for procedure preparation belongs to plant or utility engineers. Management personnel and operators at one of the sites favor this method because each on-site engineer has responsibility for all of the procedures covering a given plant system. Furthermore, the engineers who write the procedures work closely with the operations and maintenance staff so the procedures are responsive to user feedback.

At the remaining two sites, off-site engineers write procedures. In both cases operator dissatisfaction had been reported regarding the quality and usability of the procedures. Staff indicated that the procedures often were inaccurate and contained irrelevant information. Extensive revisions often were necessary, a situation not unlike that arising when outside consultants were used for procedure preparation.

Procedures are written by operations personnel at three sites. Senior operations personnel select an available operator familiar with the particular task to write the needed procedure.

BEST COPY AVAILABLE

As can be seen in Table 3.4, two plants rely exclusively on operators to write procedures and neither of these plants provides a writers' guide. Further, the operators at these plants have not received training in technical writing or human factors issues related to procedures. Writers' guides for operating procedures (other than for the new EOPs, in which case a writers' guide is required by Generic Letter 82-33) were available at only two plants visited. Staff at both of these plants had developed writers' guides for AOPs and NOPs, and staff at one of the two plants intended to develop guides for all types of plant procedures (e.g., maintenance, surveillance, etc.). These writers' guides followed the model of the plants' EOP writers' guides.

3.3.2.2 Matching user knowledge to procedures

Practices regarding the match of user skill level to procedure development also varied among the sites. Three plants have established and implemented a policy to ensure the matching of level of procedure detail to the training and experience levels of the intended users. One additional plant does not have a formal policy to write procedures for specific skill levels, but it uses a procedure review system that provides a match of skill level and procedure use. Personnel at these plants reported approaches that rely on the formatting of the procedures or on writing procedures at the lowest skill level of personnel with access to the procedure in order to link skill level and procedure use.

One plant has implemented a two-column format for procedures to allow use of all operating procedures by the highly skilled and inexperienced operator alike. Action steps are presented in the left-hand column of each procedure page; notes, explanatory material, and references are presented in the right-hand column. Experienced operators can use the left-hand column as a checklist for the actions required to complete a task, and their task performance is not slowed by the need to read through unnecessary (to them) supporting material. Inexperienced users can refer to details in the right-hand column, as needed, to accomplish the task described in the action steps.

Two plants developed procedures based on their operators' levels of expertise. In one case, operator training is heavily relied upon to assure a specified skill level. Roles and responsibilities within operations are assigned based on successful operator completion of requisite training. Operators receive two weeks of requalification training every ten weeks. Career advancement is tied to the amount of training received.

At the fourth plant, user experience is not considered when writing procedures, but is evaluated during a review process. At the point of review, the most inexperienced operator likely to use a given procedure does a walk-through to provide the procedure-preparer with feedback. Although this method may clarify procedure deficiencies for inexperienced operators, it does not guarantee that the needs of experienced operators for less detailed procedures are met.

BEST COPY AVAILABLE

Interviewees at the remaining five plants reported that operator skill levels are not formally addressed when procedures are prepared. Generally, one of two reasons was given for not addressing this issue. Interviewees either reported that their procedures were too complex for beginners, so generic guidelines are used when performing tasks, or the development of detailed procedures is avoided and emphasis is placed on a well-trained, skilled staff instead. Clearly, neither approach provides operators with the kind of information and task performance support that is offered by a procedure specifically designed to meet the needs of particular user groups.

3.3.3 Verification and Validation of Procedures

The term "verification" of procedures refers to the processes used to ensure (1) that procedures are technically correct, (2) that there is a correspondence between the procedures and the control room/plant hardware, and (3) that the language and nomenclature used in the procedures are consistent with the terms familiar to users. "Validation" refers to methods for assuring that procedures are usable by operators and that they will accomplish the objectives that they are intended to accomplish.

The reported methods for verification and validation of procedures at the sites visited range from simple desk-top reviews to elaborate scenario-based simulator tests. As can be seen in Table 3.5, the method most commonly reported for both verification and validation is a desk-top review.

Table 3.5. Methods of Verification and Validation at Sites Visited

Methods of Verification and Validation	Site Number								
	1	2	3	4	5	6	7	8	9
Desk-top review by preparer	X	X	X	X	X	X	X	X	X
Desk-top review by other	X	X	X	X	X	X	X	X	X
Control room walk-through by preparer	X	X	X	X			X		X
Control room walk-through by other			X	X		X	X		
Simulator verification and validation			X			X			

BEST COPY AVAILABLE

Interviewees reported that the procedures that are verified and validated rigorously before use are those written for safety-related equipment and systems, as defined in the plants' FSARs. Non-safety-related procedures generally are given simple desk-top reviews and then produced and disseminated. If the procedure is complex or the writer is unfamiliar with the equipment, interviewees reported that they may walk-through the procedure in the control room or at the equipment's location in the plant. None of the plants require walk-throughs for non-safety-related procedures.

Only one of the nine plants requires that walk-throughs be conducted before safety-related operating procedures are used. Staff at this site have implemented a comprehensive validation and verification process for all classes of operating procedures. All major changes (as defined by the plant manager or operations superintendent) and new procedures are reviewed by trained procedure reviewers, who are knowledgeable about plant operations, are trained in human factors practices, and are taught to verify and validate procedures. Reviews are done with the assistance of an eight-page procedure validation checklist, and procedures are validated by control room walk-throughs. This plant does not have a plant-specific simulator available for simulator validation, but operator training sessions on their generic simulator have been used to validate safety-significant NOPs, AOPs, and EOPs. A second site uses its plant-specific simulator to conduct walk-throughs, reviews, and training on new or revised procedures that affect safety-related operations.

Pretests of procedures are not seen as being of great value by most plant personnel, with the exception of staff at the two sites described above. One procedure preparer stated that the plant procedures have been in existence for so long and the operators are so familiar with them and with the plant's systems that they can accurately evaluate new procedures or procedure revisions "in their minds" without having to walk them through or use a simulator. Others noted that some procedures are simply not important enough or used frequently enough to warrant rigorous evaluation. Of course, errors in seemingly unimportant procedures can indirectly cause transients, and tasks that are performed infrequently are often performed incorrectly because operators forget important aspects of the task. Despite the requirements of the NRC Regulatory Guide 1.33 (Quality Assurance Program Requirements [Operation]) that all safety-related procedures should be reviewed, the practices reported here suggest that procedures are used to operate expensive systems and equipment that impact safe operations before their accuracy and effects have been assessed through careful verification and validation.

3.3.4 The Procedure Review Process

In addition to some type of verification and validation, procedures at all of the sites are subject to other reviews by plant staff members and review committees before they are released for use. These reviews are intended to ensure safe operations and to facilitate coordination between plant departments. Personnel at all but one of the plants stated that the review process unnecessarily delays the implementation of procedures and

BEST COPY AVAILABLE

that the reviews do not achieve their intended goals. The organizational roles of those individuals involved in procedure reviews are presented in Table 3.6.

As was found when examining the review process for maintenance procedures at other commercial nuclear power plants (cf. NUREG/CR-3817), reviews of operating procedures by plant review committees are described by plant personnel as ineffective and as creating bottlenecks in the procedure development and revision process. The plant that reported not having problems with delays in procedure dissemination had no requirement for committee reviews.

Table 3.6. Individuals/Groups that Review Procedures at Sites Visited

	Site Number								
Procedure Reviewers	1	2	3	4	5	6	7	8	9
Operations Superintendent		X					X	X	X
Engineering		X				X			
Quality Assurance		X				X			
Tech. Spec. Coordinator		X							
Plant Operations/Safety Review Committee	X	X	X	X	X	X	X	X	
Plant Manager	X	X							
Other Departments			X						X

The reason given by the interviewees for the negative impacts of requiring review committees to review all changes to procedures was that the large number of procedures to be reviewed prohibited review in any depth. Consequently, the safety implications of procedures and their impact on the balance of plant activities are evaluated in only a cursory manner. According to the interviewees, four to six months may elapse between submission of a procedure for review and its release for use. If the committee members recommend revisions, the process will take even longer.

At the plant that eliminated committee reviews, interviewees reported that plant management had changed their review process because they believed that committee reviews were unnecessary for safe operation. Currently, the procedure preparer determines if a procedure impacts activities in

BEST COPY AVAILABLE

another department and requires a review by an appropriate department member. If an interdepartmental review is deemed unnecessary, and the procedure is not safety-related, then only approvals from the procedures group supervisor and the superintendent of operations are required.

A number of interviewees stated that the practice of making temporary changes to procedures has been used to circumvent the time-consuming and inefficient review system at their plants. At six of the sites visited, operators make temporary changes to procedures with the approval of a shift supervisor. At a few sites, they also are required to seek the additional approval of the operations superintendent. At some of the plants, these changes are in effect only for the period during which the task is performed. At four of the nine plants, however, these changes accumulate without leading to a procedure revision until a certain number of them have accumulated (e.g., five at one plant) or until the procedure is due for its biennial review. This practice reduces the time required to revise procedures formally; however, the temporary change documents that accompany existing procedures were described as difficult and time consuming to read. Furthermore, interviewees reported that this practice often encourages unnecessary changes based on reactor operator preference.

All plants conduct biennial procedure reviews (Regulatory Guide 1.33; ANSI 18.7) to ensure that plant procedures are accurate and up to date. At eight of the plants visited, staff reported that these biennial reviews are usually conducted while the procedures are under review for other reasons, such as a design change. Staff at one plant conduct biennial reviews independently of other types of reviews and operators are assigned to walk through the procedure in the control room or to use it on the plant-specific simulator. These reviews are intended to address usability issues in addition to accuracy and currentness.

In summary, several practices regarding procedure preparation were found to be relatively common for the sites visited. First, few plants use writers' guides in the preparation or revision of normal and abnormal operating procedures. Second, no plants use human factors specialists or technical writers. Third, no plants use formal task analysis as a technique for procedure preparation. According to personnel interviewed at roughly half of the sites, however, an effort is made to match the skill level of the user to the level of detail and complexity of the procedure itself.

Finally, although safety-related operating procedures are verified, validated, and reviewed to various degrees at all plants, non-safety-related operating procedures are given desk-top reviews. In general, all personnel interviewed voiced the opinion that pretests of procedures are of little value and that experienced procedure writers (most often in-house engineers) are able to write them on the basis of their experience. Committee reviews are seen as ineffective because review committees are overburdened to the point of being unable to review for safety implications. A common practice of writing temporary changes to procedures has evolved because of the lengthy review process for formal procedure changes.

BEST COPY AVAILABLE

3.3.5 Distribution and Control of Procedures

Personnel at all sites reported that distribution and control of new or revised operating procedures is the responsibility of the plants' document control departments. Complete and current sets of NOPs are maintained in the control room at eight sites, while the ninth requires that operators obtain a new copy of all NOPs and surveillance procedures from document control before performing a task. Complete sets of AOPs and EOPs are kept in the control rooms of all nine plants. These procedures are usually bound in notebooks, although two plants locate individual alarm response procedures near the panels or controls to which they pertain.

Information management systems at the sites were described by plant staff as relatively unsophisticated. Three sites do not have word processing equipment available to produce and revise procedures. Only one of the plants reported maintaining procedure revision histories on computers, and only one plant uses microfiche for this purpose. Although the procedure preparers interviewed were aware that revision histories for the procedures existed, they did not often refer to the histories because they were difficult to access. At one plant in particular, this situation had led to procedure revisions that changed a section of a procedure back to what it was before the last revision.

Either document control personnel or the operators themselves are responsible for ensuring that operators use the most recent versions of procedures at the sites visited. At plants where document control personnel are responsible, operators must assume that the procedure in the control room is the most recent version. At plants where operators are responsible for assuring that the procedure they use is the most recent, the interviewees indicated that the process is a bit more cumbersome. For example, at one of these plants, before using a "working" copy of a NOP, operators must review the temporary change sheets and the pages of the controlled master procedure and then transfer all revisions to their working copy. At another plant, operators must compare the procedure revision number on the copy obtained from control room files to the revision number shown on a master procedure index that is updated twice weekly.

3.3.6 Policies on Use of Procedures

The administrative policies governing the use of procedures and the actual practices involving the use of procedures by operators varied at the sites visited. Staff at seven out of nine sites reported that operators are given the choice of whether to use AOPs and NOPs that do not involve safety systems. Only two plants required verbatim compliance with procedures and had disciplined operators for failing to use procedures or for failing to use them properly.

A policy of verbatim compliance with procedures requires operators to follow exactly each procedure step rather than deviating from the procedure when, in the operators' judgment, plant conditions call for a somewhat different response. For example, if several valves are not

BEST COPY AVAILABLE

aligned as the procedure states they should be, operators at a plant with a policy of verbatim compliance must seek formal approval from the Shift Supervisor to proceed through the procedure, whereas operators at a plant not requiring verbatim compliance may be able to deviate from the valve position list without permission.

At the seven sites not requiring the use of procedures for non-safety-related activities, plant personnel reported that several factors influence operators' decisions to use procedures. In general, procedures are used for complex tasks, such as start-up, or for tasks that are infrequently performed. Interviewees also reported that operators do not use the procedures for step-by-step guidance, but go over them before or after performing a task to ensure correct performance.

Belief in the technical accuracy of a procedure was reported to influence operators' decisions to use a procedure. Operators stated that they avoid the use of procedures with many temporary changes and revisions because the information that they seek is difficult to find and because they cannot be sure that the information contained in the procedures is accurate and current.

The frequency with which individual procedures are used varies by class of procedure. Personnel at all nine sites indicated that the most frequently used procedures are surveillance procedures. NOPs are used next most often, but primarily during plant start-up after an outage. AOPs and EOPs are used primarily during training. The only tasks for which procedures are reported to be used consistently are those for which procedure use is required by the plant's technical specifications or by NRC regulations and guidance.

3.3.7 Procedures and Training

Only one plant has formally addressed the issue of coordinating operator training and procedures development functions. At the other eight plants, exchange of information between operations and training personnel was described as occurring informally, if at all. At a few sites, interviewees reported dissatisfaction with the contribution and efforts of the training function. Problems reported by the interviewees included:

- Plant procedures are used for operator training in seven plants, but are not included in the document control process, so the training procedures may be up to three revisions out of date.

- At two plants, operating procedures are not used for training because they are too complex or are not written in sufficient detail to be understandable by trainees.

- Timely retraining on procedure revisions is not required at any of the sites visited, although all plants circulate revised procedures to operators.

BEST COPY AVAILABLE

- Errors, omissions, and usability problems in the procedures that are identified during training, particularly on simulators, are not communicated to procedures personnel.

- At two sites, training staff reported that the extensive task analyses they had conducted for training purposes are not made available for use by procedure preparers.

Training and procedures personnel were of the opinion that training and procedures serve the same ends and that emphasis on one reduces the need for the other. Procedures personnel expressed the opinion that most operating procedures are unnecessary because operators receive so much training. Training personnel reported that emphasis on the use of detailed procedures reduces the need for operator training. These individuals seemingly were unaware that increased levels of training and experience reduce the need for detail in procedures, but do not ensure that operators will remember all task steps, particularly when performing a complex task, or when fatigued or under stress. Under adverse conditions or for infrequently performed tasks, even experienced operators need some form of JPA (e.g., checklists, flowcharts) to guide their activities.

In general, procedures and training personnel agreed that increased NRC and utility management emphasis on written procedures has led to a greater reliance by operators on procedures and reduced reliance on operators' experience when decision making is required. Both trainers and senior operations personnel stated that operators are hesitant to use their own judgment in handling situations not covered by procedures, but also become impatient with procedures and that plant evolutions have been delayed because procedures do not exist to cover every circumstance.

3.4 Summary of Findings

The site visit results are summarized in Table 3.7 and described below.

- Operating procedure development is currently driven by one of three major factors: NRC activities, design changes, and operating experience at the plant. NRC activities were the most frequently reported reasons for procedure changes, and design changes were the second most frequently mentioned. Only one site reported that procedure change derived entirely from a combination of operating experience and design changes.

- Operating procedures are increasing in number and complexity. According to operators, this situation is resulting in the degradation of procedures for several reasons. Interviewees at a majority of the plants believe that the changes identified by the NRC are often unwarranted. The number of new and revised procedures also presents problems because of the amount of time required to review, verify, and implement changes.

- Temporary procedure changes are used extensively at most of the plants visited. In some cases, temporary changes are used to avoid

BEST COPY AVAILABLE

Table 3.7. Summary of Site Visit Findings

Findings	Site Number* 1	2	3	4	5	6	7	8	9
Sources of Procedure Development									
NRC	X	X	X	X	X		X	X	X
INPO					X				X
Operating Experience			X	X	X	X	X	X	X
Design Changes	X	X	X	X	X	X	X	X	X
Procedure Preparation System Traits									
Consultants	X	X	X			X		X	X
Writer's Guide		X	X						
Staff Used:									
Engineers		X				X	X	X	
Operators	X	X		X	X		X	X	X
Procedures Group		X	X						X
Method of Verification and Validation									
Desk-top Review (preparer and other)	X	X	X	X	X	X	X	X	X
Control Room Walk-through (preparer and other)	X	X	X		X	X	X		X
Simulator Validation			X			X			
Procedure Reviewers									
Operations Superintendent		X					X	X	X
Engineering (and other specialists)		X				X			
PORCs	X	X	X	X	X	X	X	X	
Plant Manager	X	X							
Other Plant Departments			X						X

*Site numbers on this table do not correspond to those on other tables.

BEST COPY AVAILABLE

the delays and difficulties associated with developing, reviewing, and implementing permanent changes. This practice can result not only in procedures that are difficult to use because of the number of temporary change orders attached, but also in procedure revisions that have not received thorough review.

- Different personnel have been used to write procedures at the sites. Most sites used consultants at the point of initial plant start-up, but now use on-site personnel. There appears to be no common pattern of staffing for procedure writing. Only two sites reported that they use a writers' guide in preparing procedures.

- Most sites use both a desk-top review and a control room walk-through to verify procedures. Only one site required control room walk-throughs to assure the usability of new or changed procedures. Only two sites reported using simulators to verify and validate procedures, although this likely reflects, at least in part, the lack of availability of simulators for that purpose.

- Procedure reviews are handled by a number of different personnel at the sites visited. Eight of the nine plants reported relying on a plant review committee for procedure review. Interviewees at all of the sites noted a major problem with current review processes, i.e., the number of procedures to be reviewed prohibits in-depth and prompt attention by committee members.

- Document control departments at the plants produce new or revised procedures. Document control was responsible for distributing up-to-date procedures at all but one of the sites visited. At this one site, operators were charged with obtaining the most up-to-date version of any required procedures. Complete and current sets of operating procedures were kept in the control rooms of those sites where document control was responsible for procedure distribution.

- Procedure use varies according to plant policy. In general, the use of non-safety-related operating procedures is left up to operator choice. Only two of the sites visited had a policy of verbatim compliance. The decision to use a procedure was reported to be affected by operator perceptions of the technical accuracy of the procedure, the frequency with which the task is performed (i.e., the operator's familiarity with the action steps), and the complexity of the task.

- Coordination of the training function with procedure preparation and use is very limited at the sites visited. Only one plant has assigned responsibility for coordinating training and procedures functions. A number of problems have evolved from this lack of coordination, including the absence of feedback from the trainers to the procedure writers.

BEST COPY AVAILABLE

- Training personnel and procedures staff indicated their belief that training and operating procedures serve the same purpose and that emphasis on one reduces the need for the other.

Conclusions and recommendations based on these findings are presented in Section 4.0.

BEST COPY AVAILABLE

BLANK PAGE

4.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this section is to summarize the major findings of the project and to provide recommendations for NRC and industry action based on these findings.

4.1 Summary

Project findings are drawn from the two key project activities: (1) a review and evaluation of a sample of written operating procedures and (2) site visits to operating nuclear power plants. In addition, the findings reflect the comments of the peer review group. A summary of the major findings is presented below.

4.1.1 Findings from the Review and Evaluation of Procedures

- Usability of Procedures

  Operating procedures, considered as a group, fell below the rating "minimally acceptable" with regard to procedure usability. (See Section 2.5.1.)

- Specificity of Procedures

  Operating procedures are often written in vague terms and lack specificity. They often fail to describe the actions to be taken by operators in a step-by-step manner, to provide clear indicators of when a particular objective has been achieved, and to indicate when the procedure has been completed and should be exited. As a result, the procedures do not provide operators with the type of specific information they need to complete their tasks. This lack of specificity particularly decreases the usability of the procedures for inexperienced operators. (See Section 2.5.3.)

- Human Factors Considerations

  Operating procedures typically do not conform to accepted human factors principles for high-quality written procedures. The procedures often lack checklists, placekeeping aids, and other tools to enhance the ease and accuracy with which a procedure can be used. (See Section 2.5.2.)

4.1.2 Findings from the Site Visits

- Number of Procedures and Level of Detail Contained in Procedures

  Plant staff interviewed during all nine site visits stated their belief that NRC requirements are resulting in too many procedures. That is, the plant staff believe that the number of procedures at their plants is too large to be easily managed by the document control system, and that many of the procedures are too complex for inexperienced operators and contain inappropriate, excessive detail

BEST COPY AVAILABLE

for experienced operators. Further, the need to write a large number of new procedures (or rewrite existing procedures to reflect changes in NRC direction) has resulted in a degradation of the quality of the procedures in the perceptions of plant personnel. Tne peer review members believe that, in some situations, plants are writing procedures as the least costly and least time-consuming way of responding to an NRC request for corrective action to a problem. As a result of these factors at the plants visited, the number of operating procedures is increasing and the quality of those procedures is often poor. (See Section 3.3.1.)

- Plant Review of Procedures

  Many plants have a system for reviewing new and revised procedures that results in long delays in formal procedure changes. In many plants, there is a requirement that all procedure changes be reviewed by a plant review committee. The number of revisions is often quite large, particularly when the changes include minor administrative changes that do not affect the technical content or the usability of a procedure. This large number of changes can result in months of delay in the review process or, at the other extreme, a cursory approval of changes without the necessary technical evaluation where it is needed. Delays also can occur between the time a change (or new procedure) becomes effective and the point at which all operations personnel are informed of and/or trained on the new instructions. At a number of sites, this situation has led to the widespread use of temporary changes that, in some cases, receive minimal review. (See Section 3.3.4.)

- Training and Operating Procedures

  There is little coordination between the training department and the individuals responsible for writing or revising operating procedures at most of the plants visited. One result is that problems with procedures that are identified during training often are not communicated to procedure preparers, with the consequence that the procedures are not revised to correct the observed problems. (See Section 3.3.7.)

- Verification and Validation of Procedures

  Only one plant required control room walk-throughs to assure that new or changed procedures concerning safety systems are usable. More often, walk-throughs, simulation, or other review techniques are used at the discretion of procedure preparation, operations, and training groups. (See Section 2.3.3.)

4.2 Conclusions

Several conclusions can be drawn from the findings presented in Sections 2.7 and 3.4 and the summary presented above. These conclusions are

BEST COPY AVAILABLE

discussed below in order to provide a basis for the recommendations and program plan that follow.

First, it appears that the NRC has provided insufficient guidance to utilities regarding the way that operating procedures should be developed (e.g., use of a dedicated writing group including human factors expertise, use of a writer's guide, and the need to verify and validate procedures before use) and the way that procedures are to be used (e.g., verbatim compliance versus use at the operator's discretion). Although NRC guidance pertaining to the development, use, and control of operating procedures is available from several sources (e.g., ANSI/ANS-3.2, Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants, 1981; U.S. Nuclear Regulatory Commission Regulatory Guide 1.33; NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, 1982; and Appendix B to 10 CFR 50, Parts V and VI), review of the guidance shows that it is neither detailed nor prescriptive. As the findings of this project indicate, the consequence of this lack of specific guidance is that how operating procedures are developed, used, and controlled at nuclear power plants varies widely across the industry.

Second, it appears that some utilities have not seen the need to allocate adequate resources for developing usable operating procedures. As was found in a study of nuclear power plant maintenance procedures (NUREG/CR-3817), utility management personnel often do not perceive the benefits of usable procedures as outweighing the costs of producing them. That some utilities are not motivated to develop usable operating procedures is demonstrated by (1) the lack of dedicated procedure writers who have technical writing or human factors expertise; (2) the lack of detailed instructions for writing procedures; (3) the lack of thorough verification and validation processes for the procedures; (4) the use of temporary changes in the procedures without requiring that such changes be made permanent, if the changes have technical merit; and (5) the lack of timely and appropriate procedure reviews. Combined with the absence of detailed, prescriptive, and easily interpreted guidance from the NRC, the apparently low utility motivation to produce procedures of good quality has led to the development of procedures of low usability at many plants.

The consequences of disseminating procedures of low usability are that operators are much less likely to use procedures when performing their tasks, or, if required to use procedures by plant administrative policy, are unlikely to use procedures correctly. Compared to a plant with highly usable, technically accurate procedures, more errors in operations can be expected from plants with procedures of low usability. Some of these errors may challenge plant safety systems and some may potentially adversely affect public health and safety.

Another consequence of insufficient NRC guidance and low utility motivation appears to be that some plants will continue to write procedures in response to NRC directives as the easy way to address certain problems, even when another method of responding to the problems may be more effective, but more expensive to implement. Thus, it is likely that the number of operating procedures will continue to increase

BEST COPY AVAILABLE

and that procedure review systems will become increasingly overburdened. Further, many of the new procedures will not be highly usable, with the result that the "procedural fix" to a problem identified by the NRC will be ineffective.

A final conclusion that can be drawn from the project findings is that some plants will not attempt to upgrade their procedures and procedures practices unless required to do so by the NRC. Certainly, this is not the case for all plants. However, the fact that only one of the plants in the site visits was using the process for writing NOPs and AOPs that they had developed in response to the NRC directive for upgrading their EOPs is an indication that industry-wide participation in a voluntary program to upgrade procedures will not work well.

4.3 Recommendations

The purpose of this section is to present recommendations regarding the upgrading of operating procedures. These recommendations follow primarily from the findings and conclusions discussed above. However, the recommendations also draw from the other four project activities: (1) the inputs of the peer review group, (2) the results of project scoping, (3) the review of literature and existing databases, and (4) the preliminary assessment of interface problems in operating procedures. Additionally, these recommendations benefit from the experience gained in related NRC-supported projects, such as those dealing with EOPs, maintenance procedures, and safety system status verification (see NUREG/CR-3807, NUREG/CR-3817, NUREG/CR-2937, and NUREG/CR-1977), as well as the collective professional experience and expertise that the team members and peer review group members brought to this project.

The recommendations that follow are also based on the assumption that the correct use of higher quality and better controlled NOPs and AOPs will enhance plant safety. That is, improved procedures will reduce the likelihood of events at plants and allow better mitigation of the consequences should they occur. In support of this assumption, the analysis of licensee event reports (LERs) for 1981 and 1982, conducted as part of this project, found that about 5% of the LERs in this time period involved operating procedures and administrative controls. Over half of these LERs, which arose from normal plant operations, involved situations in which the incorrect procedure was used or situations in which the correct procedure was identified but was used incorrectly (see Appendix B). In addition, the relationship between human error and procedural problems has been noted in other investigations of nuclear power plant safety-related systems (NUREG/CR-0153, 1978). Procedure-related problems and associated operator errors have caused plant trips. Plant trips challenge safety systems, and challenges to safety systems impact on safe operation of a plant.

4.3.1 Recommendation #1

It is recommended that the NRC, working with the industry, develop an explict set of criteria for identifying those tasks at each plant that

BEST COPY AVAILABLE

should be performed with the assistance of a procedure. Although Part V of 10 CFR 50, Appendix B, provides some information regarding which activities should be prescribed by procedures (i.e., "activities affecting quality"), this requirement is vague and may be difficult for plants to interpret. The criteria that we are recommending be developed should more specifically describe the conditions under which procedures are necessary. These criteria, of course, would have to be related to the protection of public health and safety and should reflect what is known about when and how procedures can enhance safe operations. For example, borrowing from the rationale for requiring practice on specific tasks, we could state that procedures should be written and used for tasks that are complex, infrequently performed, and critical to safety (Cream, Eggemeier, and Klein, 1978).

It is the project team's belief that the problem of too many procedures may be rooted in the apparent absence of criteria for when a procedure is needed. The presence of a rationale for determining which procedures are needed may lead to an end to the current practice of writing procedures as an easy means of resolving issues identified by the NRC.

4.3.2 Recommendation #2

The NRC should develop further guidance on plant personnel use of operating procedures. That is, the NRC should evaluate the desirability of requiring verbatim compliance with NOPs and AOPs and, if it is found to be necessary, should take appropriate steps to ensure that such a policy is followed at plants.

4.3.3 Recommendation #3

It is recommended that the NRC and the industry determine when a high-level safety review, such as those conducted by plant review committees, is required. The findings of this and other studies indicate that the existing review process of procedures is overburdened and consequently unable to adequately address safety concerns. In some cases, committee review is entirely appropriate because of the safety-related nature of the procedure change. In other cases, committee review is probably not needed. Clear criteria for what kind of review is needed for what kind of change would help to speed the review process and would help to ensure that correct, usable procedures are available to the operator as soon as possible.

4.3.4 Recommendation #4

The final recommendation is that the NRC should require utilities to upgrade the quality of operating procedures identified by the process discussed in Recommendation #1. The requirements for programmatic development or upgrading of operating procedures should follow closely the programmatic requirements for the development of EOPs (see NUREG-0899), as will be further discussed in Section 5.0. That is, the program should include the following elements:

BEST COPY AVAILABLE

- Use of updated technical documentation to serve as the tecnnical basis for the operating procedures.

- Use of a writers' guide for specifying format and content of the operating procedures.

- A verification program for ensuring tnat tne procedures are written or upgraded using the correct technical information and following the guidance in the writers' guide.

- A validation program for ensuring that tne procedure can be used by tne operator, as intended, and, if used, would guide the operator's actions to produce tne desired operating outcome.

- A training program, as needed, to train the operators in the correct use of tne procedures.

- To ensure that procedure development and revision benefit from the experience of training personnel, it is also recommended that the NRC require plants to develop an administrative mechanism to enable the integration of training experience with procedure development.

BEST COPY AVAILABLE

5.0 PROGRAM PLAN

In order to carry out the recommendations in Section 4.0, the following Program Plan is suggested for NRC implementation.

5.1 Consolidate Known Information

The first step in the program would be to consolidate all the known information about developing, using, and controlling operating procedures. This step would entail a short-term review to bring together all the available findings and recommendations on nuclear power plant procedures, including information from projects on maintenance procedures, surveillance procedures, emergency operating procedures, normal operating procedures, and abnormal operating procedures.

5.2 Convene NRC Operating Procedures Working Group

The second step in the program would be to convene an NRC and industry Working Group on the upgrade of operating procedures. The Working Group should include representation from all of the NRC offices and the Regions, since all of the offices and the Regions have some responsibilities with regard to power plant operating procedures. The purpose of the Working Group would be to consider the findings and recommendations from the summary document described in 5.1 above and to map out a plan for regulatory action.

5.3 Answer Questions Posed in the Recommendations

The Working Group's first tasks would be to address the issues posed in Section 4.0. More specifically, the Working Group would need to determine:

- Which types of procedures or which specific procedures should be included in the upgrade program.
- Whether the NRC should regulate the way that the procedures are to be used (verbatim compliance versus plant/operator discretion).
- What type of safety review should be required for a given type of procedural change.
- Whether the programmatic requirements listed in Section 4.3.4 are the requirements that should be part of the upgrade programs.

5.4 Develop Operating Procedures Upgrade Program Requirements

Once the above questions have been answered, the NRC would be in a position of determining what kind of information it would need from a plant in order to evaluate plant-specific operating procedure upgrade programs. We suggest that the operating procedure upgrade program take on the characteristics of the emergency operating procedure upgrade program (see NUREG-0899) with a few important differences. NUREG-0899 asked that plants submit a Procedures Generation Package, which was to include the

BEST COPY AVAILABLE

following items: (1) a set of plant-specific technical guidelines, which were to serve as the technical basis for the new function-based EOPs; (2) a plant-specific writer's guide, which was to specify the content and format of the EOPs; (3) a description of the EOP validation and verification programs; and (4) a description of the program for training operators on the EOPs.

In the EOP upgrade program, the NRC and its contractors evaluated plant-generated EOP development plans but not the EOPs themselves. Subsequent audits of three plants' EOPs indicated that the EOPs were not being developed in a manner consistent with the plants' NRC-approved upgrade plan. Consequently, the program outlined below takes this potential problem into consideration.

For the operating procedures upgrade program, we suggest the following approach. First, the plants would be required, as for the EOP program, to submit a plan for how plant staff will upgrade the operating procedures. This plan should include the following elements:

- A set of criteria for defining which tasks require high-quality procedures.
- A plan for specifying how, where, and by whom the procedures will be used.
- A plant-specific writer's guide specifying the format and content of the various types of operating procedures of interest.
- A description of the verification program for determining that the new or updated procedures are technically correct and are written following the writer's guide instructions.
- A description of the validation program for determining that the procedures are written at the correct level of operator expertise and that the procedures, if followed, would carry out the purpose for which the procedure is intended.
- A description of the criteria for determining what level of safety review is required for specific types of procedure changes.
- A set of criteria for determining whether operators need training on any of the new procedures or updated procedures, and if yes, a description of the program for training the operators on the new/updated procedures.
- An administrative process for gaining feedback from the training staff on needed changes in the procedures.
- A proposed revision for plant administrative procedures that deals with the development, use, and control of operating procedures to specify the new plant requirements for the operating procedures.

BEST COPY AVAILABLE

- A proposed time line for carrying out the operating procedure upgrade program.

A few comments need to be made about the above programmatic requirements. First, the plant-specific writer's guide does not pose a large amount of work for the plants, since a writer's guide had to be developed for the EOP upgrade program. Thus, for the operating procedures upgrade program, the existing EOP writer's guide would only have to be expanded slightly to include format instructions for the different types of operating procedures. Second, the verification program for operating procedures should closely parallel the EOP verification program. Third, the validation program may not be nearly as extensive as that required for EOPs. The NRC would have to decide, however, whether it wishes to specify that the validation be carried out before first use of the procedure or whether it was acceptable to be carried out during the first few uses of the procedure. Fourth, training already-licensed operators on the new procedures would probably be unnecessary in most cases, unless existing procedures are changed dramatically or unless new procedures are developed. Finally, the project team believes that a reasonable time line for making the changes to the procedures would be during the bienniel review, so that full implementation of the upgrade would occur over a two-year period. This time line would allow the work required to upgrade the procedures to be spread more smoothly across a period of time rather than requiring a major staff effort on the front end. As stated above, the NRC should evaluate the proposed program before the plant made any changes to existing procedures or developed new procedures.

One major difference in this upgrade program from the EOP upgrade program is that this program also proposes to evaluate procedures. That is, once a plant's operating procedure upgrade plan has been approved, the NRC should then require that a sample of procedures be evaluated for conformance to the plan's requirements. Thus, after a certain number of different types of operating procedures have been developed (e.g., ten different procedures), the plants would be required to send the procedures to the NRC for review. An analysis of these procedures, especially with regard to the verification aspect of the procedure, would allow the NRC to redirect plants at the beginning of procedure development, if it appeared that the procedures were not being developed correctly. This technique would address the problem that has been seen with the EOP upgrade program where procedures are not written in accordance with the plant's NRC-approved writer's guide.

Because of personnel limitations, the NRC could probably not evaluate the operating procedure upgrade plans for all plants over a short time period. Thus, a schedule should be developed to specify when each plant will send in its plan specifications and when each plant should send in a sample of its procedures that were written or upgraded under the new plan. Based on experience with the EOP upgrade program, the operating procedures upgrade program would probably need to be carried out over the period of two to four years.

BEST COPY AVAILABLE

5.5 Time Line for NRC Program

The following is suggested as a time line for carrying out the proposed program.

Task	Proposed Dates
Consolidate Known Information	Months 1 and 2
Select NRC Task Force	Months 1 and 2
Answer Questions Posed in Recommendations	Months 2 through 4
Develop Upgrade Program Requirements	Months 2 through 6
Develop Time Line for Plant Submittal	Month 6
Review Plant Program Plans and Procedures	Months 7 to End

It is recognized that the proposed Program Plan could take other directions. For example, the NRC may decide to ask the industry to upgrade operating procedures on a voluntary basis. In such a case, the Program Plan would involve collecting a technical basis for convincing the industry that upgrading of operating procedures was in their own best interest. Then an industry group, such as INPO, would probably need to develop guidance to be used by the industry. Such a program might be able to achieve the same result, but over a greater length of time. Thus, other avenues of approaching the problem are possible. However, the Program Plan set forth above, based on experience in carrying out a similar program for EOPs, but with provision to correct the potential trouble areas in the EOP program, is familiar to the industry and builds upon work already done by the industry to meet previous requirements. Therefore, in the project staff's opinion, the Program Plan outlined above has a very high likelihood of success in improving the development, use, and control of operating procedures in the nuclear industry.

BEST COPY AVAILABLE

6.0 REFERENCES

ANSI/ANS-3.2. Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants. (Revision of N18.7-1976.) La Grange Park, IL: American Nuclear Society, 1981.

Cream, B.W.; Eggemeier, F.T.; and Klein, G.A. A strategy for the development of training devices. Human Factors, 1978, 20(2), 145-158.

NRC Regulatory Guide 1.33. Quality Assurance Program Requirements (Operation), Rev. 2, February 1978.

NUREG-0660. NRC Action Plan Developed as a Result of the TMI-2 Accident, Volume 1. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1980.

NUREG-0737. Requirements for Emergency Response Capability, Supplement 1 (Generic Letter 82-33, December). Washington, D.C.: U.S. Nuclear Regulatory Commission, 1982.

NUREG-0799. Draft Criteria for Preparation of Emergency Operating Procedures. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1981.

NUREG-0899. Guidelines for the Preparation of Emergency Operating Procedures. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1982.

NUREG/CR-0153. Insights Into Improving the Efficacy of Nuclear Power Plant Inspection Procedures Based Upon Risk Analysis. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1978.

NUREG/CR-1977. Guidelines for Preparing Emergency Procedures for Nuclear Power Plants. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1981.

NUREG/CR-2837. PNL Technical Review of Pressurized Thermal Shock Issues (PNL-4327). Washington, D.C.: U.S. Nuclear Regulatory Commission, 1982.

NUREG/CR-2937. Repository Site Data Report for Tuff: Yucca Mountain, Nevada. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1983.

NUREG/CR-3807. Safety Review of Nuclear Power Plants: Recommended Guidelines (Vol. 1); and A Review and Assessment of Current Practices (Vol. 2). Washington, D.C.: U.S. Nuclear Regulatory Commission, in press;

NUREG/CR-3817. Development, Use and Control of Maintenance Procedures in Nuclear Power Plants: Problems and Recommendations. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1981.

10 CFR 50. Code of Federal Regulations. Washington, D.C.: Office of the Federal Register National Archives and Records Administration, 1985.

BEST COPY AVAILABLE

APPENDIX A

LETTER REPORT ON RESULTS OF REVIEW OF EXISTING "DATA BASES"

BEST COPY AVAILABLE

Battelle
Human Affairs Research Centers
4000 N.E. 41st Street
P.O. Box C-5395
Seattle, Washington 98105
Telephone: (206) 525-3150
Cable: HARCSEA

October 22, 1983

Dr. Michael J. Goodman
Procedures & Test Review Branch
U.S. Nuclear Regulatory Commission
MS AR 5221
Washington, DC 20555

Subject: Project P-2 Summary Letter and Report for Task 2: Results of Review of Existing Data Bases, Revision 1

Dear Mike:

This letter report is to update you generally on our work on the above-noted project, to summarize our progress on Task 2, and to incorporate your comments on the first draft of this letter dated August 15. Task 2 involves identification and review of existing studies and related data on nuclear power plant operating procedures including relevant administrative procedures and the application of job performance aids.

In attempting to identify relevant information concerning nuclear power plant operating procedures, we sought data sources that address as well current industry practices and problems. This broad scope will become clearer as our efforts to date are described.

The identification of existing data and studies on nuclear power plant operating procedures has involved three separate lines of inquiry:

- identification of government-sponsored and other research focused on or relevant to nuclear power plant administrative controls, operating procedures and operating procedure development, implementation, and evaluation;
- review of current operating practices, standards, and procedural requirements for nuclear power plants; and
- identification of procedure-related problems associated with specific operating systems, plant types and/or methods of procedure development and control at nuclear power plants.

TEST COPY AVAILABLE

Each of these lines of inquiry is discussed further below.

- Identification of government-sponsored and other research focused on or relevant to nuclear power plant administrative controls, operating procedures and operating procedure development, implementation, and evaluation.

Within this line of inquiry, efforts have been concentrated on the use of computerized literature searches. Relevant citations were gathered and materials reviewed from the following literature indices:

1. NTIS (National Technical Information Service)
2. DOE (Energy file)
3. COMPENDEX (Engineering information, etc.)
4. Engineering Index
5. DROLS (Defense Research On Line System)

In addition, this project has benefited from the extensive literature search conducted by and bibliography developed by Project P-1, Development of Guidelines for Upgrading Maintenance Procedures.

While these sources did not yield a large body of literature directly related to nuclear power plant operating procedures, a number of useful articles and reports were found. These are listed in a brief bibliography found at Attachment A. Useful references, earlier identified and reviewed by Project P-1, Development of Guidelines for Upgrading Maintenance Procedures, are also listed in the bibliography.

In general, the reviewed literature confirmed the breadth of operating procedures and underscored the importance of comprehensible, well-written procedures to guide plant operations. Also confirmed was the relationship between performance problems and related-procedure problems.

- Review of current operating practices, standards, and procedural requirements for nuclear power plants.

This line of inquiry has focused on ANS/ANSI standards and related Regulatory Guides bearing on operating procedures. Documents identified as particularly relevant here have included:

ANSI-N45.2-1971. "American National Standard Quality Assurance Program Requirements for Nuclear Power Plants," which established quality assurance standards associated with the design, construction, maintenance, and modification of nuclear power plant structures, systems, and components.

BEST COPY AVAILABLE

ANSI-N18.7-1972. "American National Standard, Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants," which focuses on power reactor operation and in particular on administrative controls over activities associated with power operation.

ANSI-N18.7-1976/ANS-3.2. "American National Standard, Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants," which attempted to provide a single standard relating to quality assurance program requirements in the operations phase, amalgamating relevant standards from both ANSI-N18.7-1972 and ANSI-N45.2-1971.

NRC Regulatory Guide 1.33. "Quality Assurance Program Requirements (Operation)," Revision 2, February 1978, which describes an acceptable method for complying with NRC regulations concerning quality assurance program requirements in operational nuclear power plants. This document endorses ANSI-N18.7-1976/ANS-3.2.

ANSI/ASME NQA-1-1979. "American National Standard Quality Assurance Program Requirements for Nuclear Power Plants," which superseded ANSI-N45.2-1971.

ANSI/ANS-3.2-1982, "Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants," a revision of N 18.7-1976 incorporating the administrative "lessons learned" following the accident of Three Mile Island and reflecting the issuance of NQA-1.

While these documents provide the current industry standards and regulatory requirements for operating procedure content, format, review, and implementation, they may or may not reflect current industry practice with respect to operating procedures.

To examine current practice, it was decided first to review the administrative controls and updated FSAR Chapter 12 "Conduct of Operations" and/or FSAR Chapter 13.5.2 "Operating Instructions" for selected nuclear power plants. These documents provide information on the organization and content of operating procedures, as well as on measures to control the development, review, and distribution of such procedures. With this content, it was felt that these documents would be useful for examining adherence to promulgated standards as well as variations in procedure content and control within the industry. Our plans called for a review of the operating procedure indices for several plants selected on the basis of geographic distribution, age, length of operating experience, size, and type of plant.

BEST COPY AVAILABLE

Relevant procedures and organizational materials from Calvert Cliffs 1 were received and reviewed, in particular "Section 12.3 Operational Procedures and Controls" from Calbert and Cliffs, and FSAR Chapter 13.5.2 "Operating Instructions" from Grand Gulf. It became clear that a review of current practice among individual plants was best undertaken in conjunction with a review of each plant's actual operating experience. For that reason, it was decided to defer selection of plants for document review and/or site visits until completion of the NRC data base analyses (described below).

- Identification of procedure-related problems associated with specific operating systems, plant types and/or methods of procedure development and control at nuclear power plants.

Within this line of inquiry, two NRC data bases are being tapped: (1) the Nuclear Safety Information Center database which contains LER data; and (2) the 766 Database file which contains inspection and enforcement data.

1. Examination of LERs

LERs for the period 1981-82 where administrative control failures or procedural deficiencies related to operations were discovered, were examined, coded, placed in an automated file, and analyzed. The results of these analyses were as follows:

Of approximately 10,000 LERs for the years 1981 and 1982, those clearly involving maintenance or emergency procedure problems were immediately excluded. The intent was to code only those LERs that concerned problems with operating procedures or administrative controls. A total of 501 LERs appeared to meet this criterion. Th[illegible] LERs fell into the following categories: surveillance (26.3%); test (20.4%); calibration (14.2%); installation (1.8%); materials control (.6%); all other categories (1.8%). The largest category, however, did not indicate the type of procedure that was the source of the LER. This category contained 175 cases or 34.5% of the total. Thus, while it may be possible that some of the 501 coded LERs relate to maintenance and emergency procedures, this number is not expected to be large since coders generally found that such procedures were more readily identifiable from the LER text than are operating procedures.

Among the 501 LERs coded, the most frequent errors involved incorrect procedures (29.7%); use of a proper procedure at the wrong time or without adequate preliminary activities (16.8%); missed deadlines for undertaking procedures (13.8%); and incorrectly performing a procedure (11.2%). Errors were most frequently identified through surveillance or the surveillance review processs (28.2%); by a system alarm or failure (12%); or through the procedure review process (9%).

BEST COPY AVAILABLE

Reasons were given for procedural errors in less than 20% of the 501 events, with the failure to update procedures (5.2%)* and ambiguous procedures (4.4%) constituting the most frequently cited causes of errors. By far the most common response to discovered errors was to revise the relevant procedures. This was reported in 57.5% of the LERs.

NRC Region appeared to play a role in the number of LERs related to operations with Region II leading with 47% of the total; followed by Region I (23%); Region III (21%); Region V (6%); and Region IV (3%). Controlling for number of plants, Region II remains dominant with an average of 8.4 operations-procedure-related LERs per operating unit; followed next most closely by Region V with 5.8 such LERs per operating unit.

2. The 766 Database

Our interest in the 766 Database was to determine the extent to which deviations or violations discovered through NRC Inspection and Enforcement activities at operating plants are procedure-related. The 1978 study by Plummer and Denning (cited in the bibliography), for example, found that risk-related system faults attributable to human error were almost always procedure-related as well. Thus, investigation of the 766 Database appeared a fruitful avenue.

The following data from the 766 file were requested for all 1981 Inspection and Enforcement documents that involved (1) construction or operating reactors, and (2) incident, enforcement, special, or vendor inspections and inquiries or investigations:

Type of inspection activity

Inspection/Investigation Findings

Type of Facility

Module Number (combined code denoting the operating phase of plant and particular system being examined)

Whether a deviation or violation existed and its severity

Text of the deviation or violation.

The text describing each violation and deviation was reviewed in order to code the type of procedure involved (e.g., surveillance, test, calibration, etc.) and the type of error associated with the violation/deviation (e.g., wrong procedure used, procedure incorrectly performed, no procedure, etc.). A total of 172

*Of total cases (N = 501).

BEST COPY AVAILABLE

violations and deviations were coded and the resulting information used to create a data file for further analysis. The vast majority of cases involved violations only (92%), with a few involving deviations only (4%), and a few combined violations and deviations (4%).

The problems most frequently identified with violations and deviations in these data involved radiation exposure (20% of the total), construction (14%), surveillance (10%), and security (9%). The majority of violations and deviations appeared to be due to procedures that were incorrectly performed (52%). Many of the problems appeared to stem from failure to perform a procedure when required (21%) and to the lack of procedure (16%). It is interesting to note that the majority of violations and deviations reported during 1981 emanated from Region II (51%).

The LER and 766 file data suggest that procedural problems are often due to difficulty or confusion in administering the procedures. For example, updating procedures, or the failure to update procedures; following ambiguous procedures; and performing procedures incorrectly were frequently noted as sources of problems. Thus, these data suggest that special attention should be focused on the administration of procedures during the subsequent study of the use of operating procedures in the industry. LER and 766 data also suggest that NRC Region may be an important consideration in selecting plants for further study of operating procedures.

Summary

The 766 file and LER data offer some guidance in the selection of procedural problems and sites for further study. In addition, several individuals familiar with operating procedures are being contacted and asked to describe any operating procedures they have observed as particularly problematic. These individuals include NRC training staff in Tennessee and license examiners at PNL. Next, the information provided by these people and the results of the 766 file and LER data analyses will be reviewed with the NRC technical monitor in finalizing selection of specific plants and areas of operating procedures for more intensive analyses.

Should there be any aspects of this report you wish to discuss in more detail, please do not hesitate to contact us.

Best wishes,

M. Morgenstern
Project Manager

MM:cs
Attachment

BEST COPY AVAILABLE

ATTACHMENT A

OPERATING PROCEDURES BIBLIOGRAPHY

Brooke, J. B., and K. D. Duncan, An experimental study of flowcharts as an aid to identification of procedural faults, Ergonomics, 1980, Vol. 23, No. 4, pp. 387-399.

Brune, R. L., and M. Weinstein, Procedures Evaluation Checklist for Maintenance, Test and Calibration Procedures Used in Nuclear Power Plants, NUREG/CR-1369, 1982.

FFTF Operating and Administrative Index, Idaho National Engineering Laboratory, Idaho Falls, Idaho, October 15, 1976 (HEDL-TI-76031-1).

FFTF Operations Procedures Preparation Guide, Revision 2, Hanford Engineering Laboratory, Richland, WA, December 1976 (HEDL-TI-76032).

Frey, P. R., and R. A. Frey, A Survey of Methods for Improving Operator Acceptance of Computerized Aids, Oak Ridge National Laboratory, Oak Ridge, TN, NUREG/CR-2586, 1982.

James F. W. Job Performance Aid Methods, Air Force Packaging Evaluation Agency, Wright-Patterson Air Force Base, Ohio, 1975.

Job Performance Aid: Job and Task Analysis, TRADOC-Pam-351-6.

Kisner, R. A., and P. R. Frey, Functions and Operations of Nuclear Power Plant Crews, Oak Ridge National Laboratory, Oak Ridge, TN, NUREG/CR-2587, 1982.

Klein, W., Operation Manuals, Standard Operating Procedures and Routine Training, Kraftwerk Union A.G., Erlangen, Germany FR, 1977.

Lewis, J. R., M. H. Morgenstern, and T. H. Rideout, Safety System Status Monitoring: Effectiveness of Procedures, Battelle Pacific Northwest Laboratory, Richland, WA, January 1983.

Luckas, W. J., Jr., V. Lettieri, and R. E. Hall, Initial Quantification of Human Error Associated with Specific Instrumentation and Control System Components in Licensed Nuclear Power Plants, NUREG/CR-2416, 1982.

McLaughlin, S. D., A Critical Survey of Potential Performance Indicators for Assessing NRC Licensees, Battelle Human Affairs Research Centers, Seattle, WA, Draft, February 1983.

NUREG-0899, Guidelines for the Preparation of Emergency Operating Procedures, Draft, May 1982.

BEST COPY AVAILABLE

Plummer, A. M., and R. S. Denning, Insights Into Improving the Efficacy of Nuclear Power Plant Inspection Procedures Based Upon Risk Analysis, Battelle Columbus Laboratories, Columbus, Ohio, NUREG/CR-0153, June 1978.

Post, T. J., and M. G. Smith, Hybrid Job Performance Aid Technology Definition, Navy Personnel Research and Development Center, San Diego, CA, 1979 (NPRDC TR 79-25).

Zach, S. E., Control Room Operating Procedures: Content and Format, Paper presented at the Proceedings of the Human Factors Society Annual Meeting, 1980.

BEST COPY AVAILABLE

APPENDIX B

LETTER REPORT ON RESULTS OF PROJECT SCOPING EFFORTS

BEST COPY AVAILABLE

Battelle
Human Affairs Research Centers
4000 N.E. 41st Street
P.O. Box C-5395
Seattle, Washington 98105
Telephone: (206) 525-3130
Cable: HARCSEA

January 31, 1984

Dr. Michael J. Goodman
Procedures & Test Review Branch
U.S. Nuclear Regulatory Commission
MS AR 5221
Washington, D.C. 20555

Subject: Project P-2 Summary Letter and Report for Task 1: Results of Scoping Efforts

Dear Mike:

This letter report is to apprise you of the results of our efforts to determine the scope of project P-2: Program Plan for Assessing and Upgrading Operating Procedures for Nuclear Power Plants. Task 1, as indicated on the P-2 revised statement of work, is designed to define which plant procedures should be classified as "operating procedures" and to determine the range of procedures that will be addressed by this project. Although the task will be ongoing through Task 6 as the focus of the project is clarified with site work and expert consultation, this summary letter report presents the results of our initial scoping efforts. We will describe the specific procedures, industry practices and procedures problems selected for further study and evaluation, and the methods used to select them. Also included in this report are the draft protocols we have developed for our site visits to nuclear power plants (Task 3: Define Current Industry Practices and Applicable Industry Standards) and to related industries (Task 4: Investigate Related Industry Approaches and Practices).

The Problem of Scope

The determination of what types of procedures should be addressed by the project is made difficult by the large number of procedures that can be classified as operating procedures. In its broadest sense, the term "operating procedures" can refer to all plant procedures, with the exceptions of maintenance and emergency operating procedures. A complete evaluation of the hundreds of procedures included in this broad definition of the term would require more time and effort than is practical. Further, many procedures among the large set of operating procedures are not likely to affect plant safety if they are poorly written or improperly used, and so fall outside the NRC areas of responsibility. The first task of P-2, therefore, has been to identify a narrower set of operating procedures and procedures problems to study.

BEST COPY AVAILABLE

Our initial efforts at defining this narrower set of procedures and procedures problems included gathering information from three sources. Because our intent was to identify operating procedures that have safety implications, our first line of inquiry was directed at records of safety problems in nuclear power plants, i.e., the Nuclear Safety Information Center database which contains LER data and the 766 Database which contains NRC inspection and enforcement data. Next, operator license examiners at Battelle's Pacific Northwest Laboratories and staff at the federal training center in Tennessee were interviewed. The purpose of these interviews was to identify procedural areas that the license examiners and trainers find to pose the greatest difficulties for operators and are most likely to lead to operator errors with safety implications. Third, we examined a sample of Institute of Nuclear Power Operations (INPO) plant evaluations that were conducted in 1981 to determine the types of procedures problems and industry practices identified by the INPO evaluators. The results of these data-gathering activities are described in the following sections.

Examination of the LER and 766 Databases

To examine the role of operating procedures in generating safety-related events and to determine the extent to which deviations or violations discovered through NRC Inspection and Enforcement activities at operating plants are procedure-related, LERs for the period 1981-82 and the 766 Database for 1981 were examined, coded, placed in automated files, and analyzed. The results of these analyses are presented in detail in the Project P-2 Summary Letter and Report for Task 2: Results of Review of Existing Data Bases, Revision 1, dated 22 October, 1983.

Out of the 501 LERs that concerned problems related to operating procedures or administrative control, the most frequent errors involved incorrect procedures. The two major causes given for procedural errors were failure to update procedures and ambiguous procedures. The most common response to discovered procedure errors was to revise the relevant procedure. Finally, approximately half of all the procedure-related LERs fell into the categories of surveillance and testing procedures.

Analysis of the 766 database revealed that the majority of violations and deviations appeared to be due to procedures that were incorrectly performed. The apparent causes were primarily failure to perform a required procedure and the lack of a procedure. Finally, surveillance problems were ranked as the third largest group of problems identified with violations and deviations. Surveillance was preceded by radiation exposure and construction-related violations. Both these categories were associated with outages or the pre-operating phase of the plants.

BEST COPY AVAILABLE

The LER and 766 file data suggest three major problems for operating procedures. First, ambiguously written procedures, as well as procedures written incorrectly present a significant problem. As a result, careful evaluation of a sample of procedures is essential to further define the situation. Next, as reflected largely in the LER data, there are problems with the control of operating procedures. For example, there was frequent evidence of failure to have updated procedures, revise erroneous procedures, and failing to meet deadlines for undertaking procedures. The 766 data indicate that the absence of procedures was a substantial source of violations.

Finally, surveillance and test procedures represent categories of procedures that deserve further scrutiny. As noted above, these two categories constituted over half of the procedure-related LERs; and surveillance represented a major source of 766 violations.

Interviews with Operator License Examiners

Because the LER and 766 Databases are maintained for reasons other than the identification of procedures problems, we felt that more detailed information about operating procedures was required to identify types of procedures that may pose problems for users and to understand in greater depth the types of problems associated with the procedures. To this end, 14 operator license examiners from Battelle's Pacific Northwest Laboratories were interviewed. Because the license examiners are responsible for preparing the licensing examinations based on each plant's set of operating procedures and interact with many examinees who use the procedures, we that these individuals would be familiar with problems associated with specific types of procedures and would be able to describe industry practices and procedures problems that they encounter.

The license examiner group consisted of examiners for plants designed by each of the four NSSS vendors: four of them are General Electric plant examiners; four are Combustion Engineering examiners; and three each are examiners for Babcock & Wilcox and Westinghouse plants. The examiners were interviewed by telephone. The interviews covered two topics: (1) Had they encountered any consistent problems with specific procedures or types of procedures, and (2) What, if any, problems had they seen or had been reported to them by examinees with operating procedures in general.

Five major issues were raised by the license examiners:

1. The Effect of the New Emergency Operating Procedures (EOPs) on the use of Abnormal Operating Procedures (AOPs). The examiners interviewed stated that the change from event-based to symptom-based EOPs has decreased the use of AOPs. The examiners noted that the AOPs are written

BEST COPY AVAILABLE

from an event-based orientation and that it is often difficult for the operators to diagnose that the entering conditions of an AOP have been met. Consequently, operators may delay action until it is clear that the entering conditions for a symptom-based EOP have been met, and then they follow the EOP, by-passing preventative measures specified in an AOP. One plant's management has completely abandoned the use of AOPs, instead relying on training to guide operator actions in abnormal situations.

2. Transitions between Types of Procedures. The license examiners noted several problems that the operators face in making transitions between operating procedures.

a. The first of these problems is that the operator may be required to use more than one procedure to accomplish a given task. The operator may be required to leave one procedure in the middle, go to some part of a second procedure, then return to the first at the same point he left or at another step. The worst case mentioned by the examiners was a task that required the operator to use three separate procedures simultaneously. Transitions like these between procedures can increase the likelihood of operator errors from confusion or from losing track of what steps have and have not been completed in each of the procedures, the examiners noted.

b. The examiners stated that transitions between procedures used simultaneously may be further complicated by differing levels of detail with which the different procedures are written. Steps in one procedure that require relatively fast action may be delayed or performance may be degraded if the steps depend on certain actions from another procedure that takes time to read because it is written in detail.

c. The third point the examiners made with regard to transitions between procedures was that upon completion of the steps in one procedure, it is often unclear what procedure should guide the operator's actions next. The examiners stated that transitions between normal and EOPs are particularly difficult for the operators because of the different orientations (event vs. symptom-based) of the two types of procedures. Two of the examiners suggested that "exit points for any given procedure should leave the system in a known, unambiguous lineup that readily interfaces with other related procedures."

3. Relationship of Training to Procedures. Again, the examiners pointed out several problems with procedures, as they related to operator training.

BEST COPY AVAILABLE

a. The examiners noted that most procedures are completely divorced from station training manuals, and do not contain any explanatory material regarding the reasons a given step must be taken. Background material should be readily available to the operators and referenced in the procedure, it was suggested, to allow the operator to make informed decisions when plant systems are in "a gray area" not covered by the procedure.

b. The examiners stated that when procedures are changed, the operators often are not trained to use the revised versions. They noted that administrative controls do not exist to ensure that operators are retrained.

c. Procedures often do not include information that would allow the operators to know if a given action has had the desired effect. The examiners felt that inclusion of this information would make procedures too long to be useful, and that instead operators should be trained on how to make this judgment.

d. The level of detail with which the procedures are written is not matched to the expected knowledge level of the operators, the examiners stated. As a result, inexperienced operators may be unable to use some procedures accurately and experienced operators may avoid the use of detailed procedures as too time-consuming.

e. The examiners also noted that no mechanism exists by which lessons learned during team training on site-specific control room simulators can lead to the upgrading of plant procedures.

4. Format and Content Issues. The examiners mentioned the following deficiencies in the format and content of operating procedures:

a. Procedures in general lack cautions, warnings, or explanations describing how fast in responding, or how sensitive particular controls are.

b. The nomenclature used in procedures does not match that displayed on the control panel.

c. Steps in procedures are poorly ordered, making it difficult for the operators to follow them.

d. Without exception, procedures lack simplified line diagrams of flow paths, interfacing systems, or power sources, so that it is difficult for the operators to understand the intent and purpose of the procedure.

BEST COPY AVAILABLE

e. Procedures often are inaccurate. For example, a procedure may refer to panel F, when panel E is intended.

f. Procedures in the control room often are "photocopies of photocopies" and are illegible.

5. Development of Procedures. The examiners indicated that procedures are not validated before they are put into use. Two examiners suggested that "all procedures should be performance tested on a simulator that is exactly representative of the reference plant's control room. Each procedure should be entered from various plant conditions with various related systems degraded to ensure that the procedure is accurate and is not rendered useless during some unforeseen happenstance."

The results of these interviews clearly indicate that the content and format of existing normal and abnormal operating procedures should be evaluated as part of the P-2 project, particularly with reference to how transitions between procedures are guided. Further, these interviews again suggested that administrative controls over the development, use, and revision of procedures require study.

Interviews with Federal Trainers

Another expert source used to identify safety-related procedural problem areas was staff at the federal training center in Tennessee. Telephone contact was made with the training director who agreed to poll the training staff for us. Training personnel identified three major problem areas, as follows:

1. Surveillance Procedures. In the trainers' views, surveillance procedures contribute to significant safety problems. These procedures often fail to provide guidance on how to return a system to a normal operating mode, with the result that the system may be left inoperable following execution of a surveillance task.

2. Transitions between Normal/Abnormal EOPs. In particular, the trainers felt that EOPs tend to state "once you regain . . ., revert to normal operating instructions." The transition to a normal procedure is often impossible, however, because the system has been degraded. The result is that operators are required to improvise, with unknown consequences.

BEST COPY AVAILABLE

3. Re-entry Conditions for Normal Operating Procedures. The trainers stated that normal operating procedures are optimally organized only if plant conditions make it possible to enter the procedure at the first step. Returning to these procedures from other plant conditions, however, is not well-guided; the operator cannot begin at Step 1 because the plant is not in the necessary state for Step 1 to be relevant. Again, operators are left to improvise.

The issues raised by the trainers concur with the findings from the analyses of the LER and 766 files as well as with the results of our interviews with the license examiners. Like the examiners, the trainers emphasized the problem of transitioning between procedures. And, as was found from the LER and 766 analyses, surveillance procedures can have a significant impact on plant safety and should be evaluated as part of this project.

INPO Plant Evaluations

Reports of 17 INPO plant evaluations that were conducted in 1980-81 and had been released to the public were made available to us from another Battelle project. The section of these reports that pertains to operating procedures (i.e., "Operations Procedures and Documents") were content analyzed, and the following list of procedures problems was compiled to aid our scoping efforts.

1. Procedure Control. Procedure problems in this area pertained to the preparation, review, approval, and revision of operating procedures. Deficiencies noted included:

a. One plant had not designated procedure review periods.

b. One plant had no mechanism to review, retain or incorporate temporary changes to procedures.

c. One plant failed to periodically review procedures that were infrequently used.

d. One plant failed to incorporate temporary changes to procedures into a permanent revision within the time prescribed by administrative procedures.

2. Procedure Content and Format. Procedure problems in this area were noted if procedures lacked clarity and conciseness, or failed to provide adequate information for users to understand and perform their activities effectively. Deficiencies noted were:

BEST COPY AVAILABLE

a. Three plants used as operator aids uncontrolled notes, graphs, portions of procedures, and labels and drawings of a temporary nature attached to control panels at various plant locations.

b. The content and format of abnormal operating procedures at one plant were inconsistent, with the result that some procedures lacked sufficient information and others were unwieldy.

3. Availability and Identification of Procedures. Procedure problems in this area pertain to the difficulties operators face in accessing procedures. Problems identified here included:

a. At one plant the index of procedures was too lengthy to permit easy identification of the appropriate procedure.

b. One plant did not uniquely identify emergency and off-normal procedures: the color of the binders used for these procedures was the same as that used for all operating procedures, no separate indices were provided, and there was insufficient tabbing to separate individual procedures.

c. At one plant, index descriptors of the procedures did not clearly communicate the content of the procedures.

4. Procedure Use. Problems in this area concern the adequacy of procedures governing the use of procedures. Six plants were deficient in this area and lacked policies to specify which procedures were to be used only as general guidance or to be used in-hand when performing the task.

The findings noted in the plant evaluations provided us with additional evidence to support the need for evaluating administrative controls over the preparation and use of procedures as well as for examining the content and formulat of procedures. Further, the plant evaluations suggested the need for site visits to nuclear power plants as a way to investigate industry practices, such as the use of uncontrolled notes or tags on equipment, that cannot be evaluated from desk-top reviews of procedures.

Conclusions

The results of our scoping efforts thus far led us to several conclusions that will guide our future data-gathering activities.

BEST COPY AVAILABLE

1. The content and format of normal operating, abnormal operating, and surveillance procedures should be evaluated, particularly with respect to how these procedures guide transitions to other procedures.

2. Administrative policies concerning the development, use, revision, and control of operating procedures and the training of operations personnel to use procedures should be evaluated.

3. Industry practices governing the media (e.g., JPAs such as placards and labels and packaging techniques) through which operating instructions and information is made available to operators should be assessed.

Further Activities

In light of these conclusions based on our initial scoping efforts, the project team has opted for a two-tiered approach to the evaluation of operating procedures, procedures problems, and industry practices relevant to operating procedures. These strategies include (1) conducting site visits to nuclear power plants, as described in the site visit protocols presented in Appendix 1, and (2) conducting desk-top reviews of a small sample of normal operating, abnormal operating, and surveillance procedures from all operating nuclear power plants. In consultation, again with the license examiners, we are currently in the process of selecting the procedures for review. Our preliminary list is presented in Appendix 2.

Should you wish to discuss any aspects of this report in greater detail, please contact us at your convenience.

Best wishes,

Michael H. Morgenstern
Project Manager

MHM/ad

cc: V. Barnes
J. Faigenblum
M. McGuire
L. Radford
W. Rankin
M. Walsh
R. Badalamente, PNL
L. Defferding, PNL
R. Widrig, PNL

BEST COPY AVAILABLE

APPENDIX C

LETTER REPORT ON RESULTS OF PRELIMINARY ASSESSMENT OF INTERFACE PROBLEMS

BEST COPY AVAILABLE

Battelle
Human Affairs Research Centers
[illegible] NE 41st Street
P.O. Box [illegible]
Seattle, Washington 98105
Telephone 206/525-3150
Cable: BATSEA

March 1, 1985

Dr. Michael J. Goodman
U.S. Nuclear Regulatory Commission
AR-5221
4550 Montgomery Avenue
Bethesda, Maryland 20814

Subject: Preliminary Assessment of Interface Problems

Dear Mike:

The purpose of this draft letter report is to apprise you of the results of our preliminary assessment of interface problems among the procedures of operating nuclear power plants (NPPs) in the U.S. The preliminary assessment was undertaken as part of Project P-2: Program Plan for Assessing and Upgrading Operating Procedures for Nuclear Power Plants, Task 3: Define Current Industry Practices and Problems.

This letter report draws upon four sources of information: (1) the findings of several NRC-sponsored projects previously completed by Battelle; (2) initial Project P-2 scoping efforts in which procedure interface problems were identified; (3) information obtained in P-2 site visits to nine operating nuclear power plants (NPPs); and (4) comments of the P-2 Peer Review Group during the second review group meeting discussion of interfaces (Seattle, 4 December 1984) and their responses to the first draft of this letter report. Each of these information sources is discussed separately below, and several types of procedure interface problems are identified. Finally, this report offers several conclusions and recommendations for further action to assess the nature, scope, and safety significance of procedure interface problems.

As you know, the primary purpose of this letter report is to describe the types of interface problems found among NPP procedures to date. We are looking forward to beginning the new project on procedure interfaces so that we can build upon this preliminary assessment and increase our understanding of problems in this area.

BEST COPY AVAILABLE

Findings of Prior Projects

Problems resulting from interfaces between NPP procedures were first identified in three previous projects conducted by Battelle for the NRC. Project-related activities and findings showed that users of procedures experience problems when they have to go from one type of procedure (e.g., emergency operating procedures) to another (e.g., an abnormal procedure). They also experience difficulties when they have to move from one procedure to another even when these procedures are of the same type. The three prior projects are described below, but only those portions of the projects pertinent to interface problems are reported here.

The Review of Emergency Operating Procedures (EOPs) for Near-Term Operating Licensees project was undertaken to assess the adequacy of plant EOPs from both a technical and human factors point of view. EOPs from a number of plants were given desk-top reviews (to verify that the EOPs were consistent with owner's group and plant technical guidelines and were consistent with good human factors writing practices) and simulator reviews (to verify that the operators could actually perform the EOPs as written and that the EOPs would actually mitigate the emergency event). The desk-top reviews revealed that transitions between EOPs and other procedures governing abnormal and normal operations were neither clearly marked nor clearly described in the procedures. Also, other procedures often were referenced without specification of which steps were to be followed in the referent procedures.

During simulator exercises, it became apparent that the interface deficiencies identified in the desk-top reviews made the procedures difficult for operators to use under changing plant conditions. The operators often had difficulty deciding what procedures they should be following at a particular point in time, and the operators' responses to events were delayed as they sought out the other procedures or parts of other procedures referenced in the EOPs. In addition, operators experienced difficulty in finding the correct place to enter a referenced procedure and in deciding whether or not steps in a referenced procedure were to be followed concurrently with the EOPs.

The Safety System Status Verification project addressed the question of whether or not operating crews in NPPs had the information available to verify the status of plant safety systems in all phases of operations. Of particular interest in this project were interfaces among administrative, surveillance and operating procedures when 1) removing or disabling a piece of safety-related equipment for maintenance or to perform surveillance tests, 2) returning that equipment to service, and 3) verifying that these tasks were performed correctly. One of the significant findings of this project was that the procedures which supposedly "interfaced" with other procedures were often vague and incomplete, sometimes contradicted the

BEST COPY AVAILABLE

related procedures, and, in some cases, were unnecessarily lengthy and complex. The consequences of these interface deficiencies were that operators and other users were at times unable to verify the availability of safety systems and so were in danger of violating the plants' technical specifications.

The Pressurized Thermal Shock (PTS) project was concerned with the consequences of introducing large quantities of relatively cold water into a hot reactor pressure vessel (RPV), the welds of which had been embrittled because of neutron bombardment. One of the claims made by the industry was that operators could handle the situation by cooling down the plant at a rate that would not endanger the integrity of the RPV. The operators could perform this very difficult task, it was claimed, because they would be properly trained and would use the proper procedures. The procedures involved were several abnormal and normal operating procedures that had to be used simultaneously.

Following extensive study of the PTS situation and evaluation of the industry's claims, project personnel concluded that operators would have serious difficulties in transitioning between the procedures involved, particularly during a highly stressful situation. It was suggested that the operators' difficulties would be essentially the same as those encountered during emergency conditions where the controlling procedures were EOPs.

The findings of these three projects suggest that procedure interfaces present problems to users of NPP procedures that can lead to degraded and delayed task performance, and to the possible violation of plant technical specifications. Further, these projects' findings indicate that interface problems exist among NPP normal, abnormal, and emergency operating procedures as well as between surveillance and administrative procedures.

Initial P-2 Scoping and Problem Identification

The results of our scoping efforts for project P-2 provided additional evidence that procedure interfaces present difficulties to operators when using normal and abnormal operating procedures. These findings were reported in detail in our Summary Letter Report of 31 January 1984, and are briefly summarized here.

Fourteen license examiners and staff at the NRC Reactor Training Center in Chattanooga, Tennessee stated in telephone interviews with P-2 project staff that they had noted procedure interface problems of varying degrees of seriousness in all of the NPP procedures with which they had worked. The interface problems they reported included the following.

Interfaces Between Types of Procedures. The license examiners stated that interfaces between abnormal operating procedures (AOPs) and the new

BEST COPY AVAILABLE

EOPs are particularly difficult for operators to manage because of the different orientations of the two types of procedures in most plants (i.e., event vs. symptom-based or function-based). Differences in the formats used and the level of detail with which the procedures are written, as well as a lack of specific exit and entry information in both types of procedures contribute to operator confusion in identifying the steps they are to follow when moving between procedures.

The training people at the Federal Training Center made a similar point regarding transitions from AOPs or EOPs to normal operating procedures (NOPs). They noted that the exit instructions for EOPs and AOPs often state, "once you regain ..., revert to normal operating instructions." However, an NOP often cannot appropriately be used to guide the operator's next actions because system functioning has been degraded. As a result, the operator is left to improvise.

References to Other Procedures. The license examiners also stated that all three types of operating procedures (i.e., EOPs, AOPs and NOPs) often require the operators to use more than one procedure concurrently or serially to accomplish a given task. In particular, NOPs frequently refer the operator to other NOPs, which govern tasks they are to perform before continuing on in the first procedure. The worst case mentioned by the examiners was an NOP that required the user to track activities governed by three procedures simultaneously. The operators experienced great difficulty in coordinating the activities described in the procedures.

In addition, the license examiners noted that interfaces between procedures are made even more difficult for operators because different procedures (even within the same class of procedures) often are written at varying levels of detail. They suggested that safety may be degraded as the operator searches for the relevant information in a lengthy and complex procedure when a task must be performed within a time limit.

As was indicated by the findings of the three prior procedure-related projects, the results of the interviews with the federal trainers and license examiners suggest that interfaces between NPP procedures cause problems for procedure users. More detailed information about different types of interface problems was gathered in P-2 site visits to operating NPPs across the U.S.

Site Visits to Nuclear Power Plants

The purpose of the site visits was to gather information regarding current practices and problems with NOPs and AOPs across the commercial nuclear power industry. Table 1 shows that the sites visited varied widely in terms of years of operating experience, size, vendors and architect-engineers. At all sites, project staff interviewed plant managers

BEST COPY AVAILABLE

TABLE 1

SUMMARY OF SITES VISITED
N = 9

TYPE OF PLANT:	BWR	1
	PWR	8
NUMBER OF UNITS:	1	5
	2	3
	3	1
YEARS IN OPERATION:	2	2
	7-8	3
	10-11	3
	17	1
NSSS VENDOR:	WESTINGHOUSE	4
	GENERAL ELECTRIC	1
	BABCOCK & WILCOX	3
	COMBUSTION ENGINEERING	1
ARCHITECT-ENGINEER:	BECHTEL	3
	FLUOR	1
	STONE & WEBSTER	1
	UNITED ENGINEERS & CONSTRUCTORS	1
	BURNS & ROE	1
	GILBERT	1
	UTILITY	1

BEST COPY AVAILABLE

or other supervisory personnel, individuals responsible for the development of procedures, operator training personnel (at most sites), and operators on duty in the control room.

An interview protocol was developed to guide interviews with these individuals. The protocol included the following questions concerning procedure interfaces:

1. Following the completion of all the steps in a procedure, is the user referred to another procedure that governs his or her subsequent actions?

   If yes, does the reference typically direct the user to a procedure by title, section, page and/or step number?

   If no, how does the operator know what further actions are required?

2. When a procedure refers the user to a second procedure, does the second procedure reference the first as an entry condition for use of the second?

3. If the user is referred to a second procedure while in the middle of the first, does the first procedure indicate at what step in the second procedure the user is to begin?

   Does the second procedure tell the user when (i.e., under what conditions) to return to the use of the first, and at what step to begin again following the first procedure?

4. Is a user ever referred to more than one other procedure or document to complete a task governed by any of the plant's operating procedures?

   If yes, what is your estimate of the percentage of AOPs that require more than one interface with another procedure or document? The percentage of NOPs?

5. To what extent do procedure interfaces cause problems for operators when performing a given task?

The interviewees differed in whether or not they perceived procedure interfaces as creating task performance problems for operators at their plants. In general, the users of procedures--operators and trainers--reported problems from procedure interfaces more frequently than procedure preparers or personnel at higher levels in the plants' management hierarchies. The supervisory personnel and procedure preparers indicated

BEST COPY AVAILABLE

that procedure interfaces had led to some problems in the past, but that they believed that effective solutions to these problems had been devised. In contrast, the individuals who use the procedures most often, i.e., operators and trainers, reported that interface problems continue to exist. The most significant problems are use of multiple procedures and the transition between procedures. These are discussed below.

Use of Multiple Procedures to Perform a Task. At six of the nine plants visited, operators reported problems caused by the requirement to refer to and follow more than one procedure to perform a task. References to other procedures were described as most common in EOPs, where the operators are referred to AOPs, and in the NOPs governing plant start-up activities, where the operators are referred to other NOPs.

The most frequently cited problem resulted from references to other procedures while in the body of a first (source) procedure. The problem is that of knowing when to do what in the source procedure, including keeping your place in that procedure, while following the steps in one or more additional procedures. Operators at five of the plants reported that it is difficult to remember what steps in a source procedure have been completed when returning to that procedure from a referent procedure.

At two plants visited, operators reported that placekeeping is made even more difficult by multiple tiers of references to other procedures. At these plants, some of the NOPs and EOPs refer the users to a second procedure, that procedure then refers them to a third, and so on. The worst case described by the operators at one plant is an EOP that requires them to track and to coordinate activities in five referent procedures simultaneously.

At another plant, placekeeping difficulties had arisen when the activities governed by a referent procedure had not led to the expected outcomes. To obtain the desired plant conditions, the operator found it necessary to use a different procedure from the procedure specified by the source procedure. However, the different procedure that was used included some steps like those in the source procedure, so it was unclear to the operator where to re-enter the source procedure.

In addition to placekeeping difficulties, operators at three plants reported that references to other procedures from a source procedure delay task performance while the operators attempt to locate the referent procedures. The operators stated that locating one AOP referenced in a source procedure is not a significant problem for them, because there are relatively few of this type of procedure and they are bound together in notebooks kept within easy reach in the control rooms. However, locating an NOP among the hundreds of NOPs listed in the plants' master procedures indices was described as time-consuming and a disincentive to use the NOP by

BEST COPY AVAILABLE

the operators. Locating more than one AOP or EOP to complete a particular task also was cited as leading to delays in task performance.

Operators who had been involved in simulator validations of one plant's new symptom-based EOPs were especially concerned with the reference issue. At this plant, both EOPs and AOPs have been rewritten in the same format so differences in the formats of the two types of procedures are not a problem to the operators. Rather, the problem identified by the operators was that nearly all (90%) of the new EOPs require the operators to refer to one and usually more EOPs and/or AOPs while following the source EOP.

In addition to placekeeping problems caused by these multiple references, the operators reported difficulty in finding the referent procedures quickly and in having enough tabletop or counter space in the control room to lay out all of the referent procedures. The operators stated that in some simulator exercises, neither they nor the supervisory personnel observing the exercises had been able to follow the procedures. To control the simulated emergency plant conditions, the operators found it necessary to abandon use of the procedures altogether and instead to rely on their experience and training. The operators at this plant believed that the new EOPs and AOPs are poorly designed and are the cause of their difficulties. The procedure preparers, plant manager and operations superintendent, however, attribute the operators' difficulties to lack of familiarity with the procedures and to the operators' resistance to change.

The training personnel with whom we spoke at four of the plants also reported that references to other procedures interfere with or delay operator task performance. They noted that managing references to other procedures is significantly more difficult for inexperienced operators than for experienced operators. They also indicated that both placekeeping and locating referent procedures cause problems for inexperienced operators in simulator exercises. At none of the plants visited, however, are operators trained to locate the procedures required for a given task. We also did not see effective master indexing systems and/or procedures that were specifically designed to aid the user in finding the right procedure(s) and the right steps within the procedure(s).

As previously noted, the license examiners we interviewed believed that references to other procedures from the main body of a source procedure present significant problems to operators in task performance. The operators and trainers interviewed in the site visits suggested further that the severity of the problems depends upon the number of references to other procedures from a source procedure and upon the operator's degree of experience in working with the procedures.

Transitions Between Procedures. None of the operators interviewed indicated that transitions between classes of procedures (i.e., moving from

BEST COPY AVAILABLE

an EOP to an AOP) present them with substantial problems. The operators stated that they know which class of procedures to enter for the various plant conditions and that exit or entry conditions included in procedures neither interfere with nor aid their abilities to transition between procedures.

In contrast, the training personnel interviewed at plants indicated that transitions between types of procedures create significant problems for inexperienced operators. The trainers suggested that lack of specific exit information in procedures and the novice operators' unfamiliarity with the content of many procedures make it difficult for them to select appropriate procedures for all plant conditions.

Further, the trainers reported that transitions between types of procedures, where the procedures are written at different levels of detail, confuse inexperienced operators. In particular, transitions to procedures written without extensive explanatory material were reported to lead to operator difficulties because inexperienced operators may not be able to find necessary information in a less detailed procedure or know at which point to begin following the procedure. The trainers also indicated that problems due to transitions between procedures are exacerbated for inexperienced operators when the operators are required to act under time pressure.

Solutions to Interface Problems. The techniques used to ameliorate problems from procedure interfaces varied at the NPPs visited. At all of the plants, however, individuals responsible for writing NOPs reported that they attempt to limit the number of references to other procedures from source procedures when developing new procedures or revising existing ones. Personnel at one plant indicated that they had reduced the percentage of their NOPs that refer the user to another procedure to no more than 10 percent.

Operations supervisors and procedure writers at two plants stated that they rely upon training and operator experience to deal with procedure deficiencies, including interface problems. At one of these plants, the plant manager reported that many of the plants' separate, shorter procedures are being incorporated into longer procedures to reduce the overall number of procedure interfaces. Although the supervisory personnel at these two plants were satisfied with their solutions to interface problems, operators and trainers still reported that the lack of clear exit and entry instructions in the procedures make them difficult for inexperienced operators to use. Further, locating procedures and the use of procedures are not emphasized in these plants' training programs, so it did not appear to the interviewers that training is provided to inexperienced operators that would help them in using multiple procedures.

BEST COPY AVAILABLE

At one plant, all personnel interviewed reported that references to other procedures from source procedures, as well as transitions between types of procedures, had created significant problems for operators. To minimize interface problems, the operations superintendent and procedure writers developed flow charts to assist the operators in tracking activities governed by complex procedures or by procedures that reference other procedures. Clear exit instructions that include direction to the next applicable procedure also were added to each of the plant's NOPs to improve transitions between procedures. Personnel at this plant generally were satisfied with the results of these modifications, although the operations superintendent reported that operators occasionally come to a "dead-end" when transitioning between procedures because not all possible plant conditions have been identified and addressed in the procedures.

At another plant, interface difficulties have been addressed in three ways. First, when procedure writers find it necessary to refer the user to another procedure from the main body of a source procedure, the reference in the source procedure is specific (i.e., by title and procedure number), clearly marked, and the user is referred to a particular section or to certain steps in the referent procedure, rather than to an entire procedure. Second, the prerequisite section of every NOP itemizes the action steps that must be completed before beginning the referent procedure. This section also provides a description of the plant conditions necessary for the procedure to be used. Third, the exit instructions for each procedure specifically reference the procedures to be followed next. Both experienced and inexperienced operators reported that they do not find procedure interfaces difficult to manage at this plant.

Summary. The results of the site visits indicated that references to other procedures and transitions between types of procedures can interfere with operators' task performance, particularly if the operators are unfamiliar with the procedures to be used or are inexperienced. Well-constructed entry and exit instructions for each procedure, reductions in the number of references to other procedures, flow charts to track activities, procedures written at a consistent level of detail, and assistance to operators in locating procedures are ways currently used to decrease problems arising from procedure interfaces in NPPs.

Peer Review Group Input

The findings of the prior Battelle projects, P-2 scoping activities and the NPP site visits described above were presented to the members of the P-2 Peer Review Group at the second Review Group meeting held on 4 December 1984. Review Group members, in general, agreed that procedure interface problems can impair the safety of NPP operations. Their specific comments on the site visit findings are presented next, as are their comments on an earlier draft of this letter report.

BEST COPY AVAILABLE

Review group members suggested that operators' difficulties in quickly locating necessary procedures represent a significant safety issue. While the group members agreed that training in locating procedures could be helpful to solve this problem, they indicated that training may not be the best solution. One group member perceived the location issue as a problem of procedure control, rather than a training problem, and suggested that improvements to the indexing systems used at plants could increase the accessibility of procedures. Another group member stated that training should not be ignored in addressing the location problem, because he believes that no matter how well an indexing system is designed, operators must be somewhat familiar with it to use it effectively, especially under time pressure. A third group member reported that the ease with which operators locate alarm response procedures at his plant has been increased by marking annunciators with the numbers of the relevant procedures.

Review group members also agreed that references to other procedures from the main body of a source procedure could cause difficulties for operators. Group members pointed out, however, that references to other procedures from plant start-up procedures may not impact safe operations because plant conditions at start-up are neither unstable nor potentially dangerous. There was no disagreement within the group on this point. In an abnormal or emergency situation where prompt action is necessary, however, review group members indicated that the number of references to other procedures should be minimized. When prompt action is required, the action steps should be included in the basic procedure.

One peer review group member discussed an interface problem not identified during the site visits. This individual stated that procedure writers at his plant sometimes lose track of some of the other procedures affected by changes to one particular procedure. As a result, references in a source procedure might refer the user to a procedure that is no longer available or to a section of a procedure by an incorrect number. He noted that currently there is no system at his plant, or at any others of which he is aware, to record the relationships among the plants' procedures. In commenting on the previous draft of this letter report, one group member again pointed out this possible consequence of detailed references to other procedures. He noted:

> There is an interesting "Catch 22" in the interface issue. According to your site visits, transitions between procedures may be best handled by specific references to particular sections or certain steps of the referent procedures. This high level of detail in procedure references is exactly what makes a system of procedures difficult to maintain. A change to one procedure may affect many others. Without careful attention to the interface, erroneous references will occur.

BEST COPY AVAILABLE

Review group members did not support the position of some operations managers that operator experience can be relied upon to ameliorate interface problems. They pointed out that the composition of the operations workforce at most NPPs is constantly changing. Therefore, procedure interfaces designed for experienced operators become less usable when experienced staff leave or when new employees are hired. For example, one group member reported that the retirement of several senior operators at his plant had created the necessity to re-write a number of procedures, because the new operators had difficulties with the procedure interfaces that the more experienced operators had not encountered. To circumvent this problem, procedures at another group member's plant are written on the assumption of no operator experience, and so careful attention is given to the interfaces among procedures.

In comments on an earlier draft of this letter report, one group member pointed out that there are a number of ways to address the problem of changing staff composition, in addition to writing procedures for the least experienced operator. Procedures written in dual-column format, with action steps located in one column and detailed explanatory information and additional guidance provided in the other, can ease interface problems for novice operators. Alternatively, procedure interfaces can be designed for a particular level of operator experience and then novice operators can be given the training necessary for them to use the procedures effectively. This review group member noted that the NPPs with which he is familiar address the issue of operator experience/interface design differently, and he stated that he is not sure that any one solution is superior to the others.

Review group members stated that they possessed minimal information about problems arising from transitions between types of procedures. However, one group member reported that procedure writers at his plant anticipated transition difficulties for operators between the new style EOPs and the plant's existing AOPs, so they have re-written the AOPs and changed the AOP format to make it consistent with their new dual-column, symptom-based EOP format. The two group members currently working at nuclear power plants volunteered to investigate the transition issue in greater depth when they returned to their plants and to convey the information they gathered to project staff.

These two group members reported that they presented the interface discussion topics included in the P-2 site visit protocol to senior operations personnel at their plants. The senior staff indicated that transitions between different types of procedures do not seem to present operators with any greater difficulties than references between procedures of the same type. Other interface problems reported by the senior staff at these plants did not differ from those identified in our site visits to other NPPs.

BEST COPY AVAILABLE

Finally, the Review Group members suggested that the procedure interface issues identified in the preliminary assessment are worthy of further study. It was the opinion of the group members who have personal experience in plant operations that task performance problems for operators caused by procedure interfaces have not been previously addressed in many NPPs. It was the consensus of the group that any future review groups formed to study and comment on interface issues should have some members who have experience with the actual development, evaluation and use of operating procedures in NPPs.

Conclusions and Recommendations

The purpose of this report is to summarize our preliminary assessment of the extent of the interface problems affecting the user of normal, abnormal and emergency operating procedures. Our assessment is based upon what we have learned during the course of several previous projects conducted by Battelle for the NRC as part of the Division of Human Factors Safety Technology Program, in addition to the P-2 project activities reported here. Clearly, we have gathered information that represents actual experience in the use of procedures at operating plants.

In reviewing the information we have obtained, it is apparent that procedure interface problems exist and that these problems are serious enough to warrant further investigation. Our activities to the present, however, have not identified the causal mechanisms that lead to the interface problems.

Our experience in those areas of human factors that deal with procedure-type issues, in addition to our knowledge of the procedures literature, does allow us to hypothesize about some of the causes of interface problems. The basic issue is one of information flow from the procedures to the procedure user and factors which appear to degrade that process. Some of these degrading factors seen at operating plants are:

1. The requirement to follow several procedures concurrently to complete a task.

2. Inconsistent levels of detail among procedures.

3. Construction of interfaces that are inappropriate for use by operators at different levels of experience.

4. Master indexing systems that do not aid the user in locating the desired procedure.

It is our recommendation that the primary thrust of the new project on interface issues be to understand as many as possible of the key causal

BEST COPY AVAILABLE

factors leading to interface problems and to develop guidelines for the procedures writer that will help the writer to minimize interface problems. One of the benefits of such an approach will be that writers, trainers, and users of procedures will become aware that some of the hitherto undefined problems with control room operations are the result of correctable procedures interface problems.

Sincerely,

Mike Morgenstern

Michael H. Morgenstern
Project Manager

MHM/sbs

cc: Jim Clifford

BEST COPY AVAILABLE

APPENDIX D

OVERVIEW OF THE PEER REVIEW GROUP MEETINGS
AND PEER REVIEW GROUP MEMBERSHIP

BEST COPY AVAILABLE

APPENDIX D

OVERVIEW OF THE PEER REVIEW GROUP MEETINGS
AND PEER REVIEW GROUP MEMBERSHIP

The first meeting of the group was held July 19-20, 1984. All members of the group were present. The specific items discussed at the meeting were:

1. The criteria for choosing the plants to be visited.

2. The questions to be asked during the plant visits and the types of persons who should be interviewed.

3. The types of procedures that should be requested from each operating plant.

4. The criteria that should be used to evaluate the procedures.

The second peer review group meeting was held December 4-5, 1984. Two members of the group were absent and later asked to be dropped from the group because of conflicts with their jobs. The second meeting focused on two items:

1. Our finding from the plant visits.

2. A discussion of the nature and magnitude of the interface problems within and between normal, abnormal, and emergency operating procedures. In January 1985, the peer review group received for comment our summary letter report to the NRC on the preliminary assessment of the interface problems.

The six members of the peer review group and their professional affiliations at the time the review group was formed are as follows:

David B. Rose
E.I. du Pont de Nemours & Co.

Max J. Clausen
Energy Incorporated

James W. Dutton
Detroit Edison

George I. Coulbourn
Boeing Engineering & Construction Co.

Vincent Roppel
Florida Power Corporation

Thomas J. Triggs
Monash University

BEST COPY AVAILABLE

APPENDIX E

PROCEDURE REVIEW AND EVALUATION METHODOLOGY AND RESULTS

BEST COPY AVAILABLE

Table of Contents

Appendix E	Page
Procedure Review and Evaluation Methodology and Results	E-1
Tables 1 through 37	E-5
Operator Procedure Rating Form	E-53
Plant Procedure Rating Form	E-55
Letter to Plant Managers	E-57

BEST COPY AVAILABLE

APPENDIX E

PROCEDURE REVIEW AND EVALUATION METHODOLOGY AND RESULTS

I. Procedure Review and Evaluation Methodology

The methods used to review and evaluate procedures involved (1) developing rating forms to record reviewer's judgments and comments on the procedures; (2) identifying a sample of procedures for review; (3) contacting all sites with operating nuclear power plants and requesting copies of six of their procedures; (4) reviewing the procedures; and (5) analyzing the results of the review. In order to supplement Section 4 of this report ("Review and Evaluation of Operating Procedures"), each of these is discussed below.

A. Developing Procedure Evaluation Rating Forms

Two rating forms were developed in order to guide and structure the review of operating procedures. The first form, the "Procedure Rating Form," contained a total of 34 items concerning the format, style, and content of the operating procedure being reviewed. Items in the form were adapted from several sources, including NUREG/CR-1977, Guidelines for Preparing Emergency Procedures for Nuclear Power Plants; NUREG/CR-0799, Draft Criteria for Preparation of Emergency Operating Procedures; and writer's guides provided by staff at plants visited as part of this project. These items were selected and adapted for inclusion on the rating form to focus the review on the usability of procedures.

In addition, a brief rating form, the "Plant Procedure Rating Form," was developed to record the total number and type of procedures reviewed for each site and the consistency of the format between different procedures from the same site.

The initial rating forms were reviewed by the NRC technical monitor and pilot tested by project team members who served as reviewers. On the basis of the reviews and pilot testing, several modifications were made to the forms. Copies of the final versions of the forms are found on pages E-53 to E-55, below.

B. Identifying a Sample of Procedures for Review

In identifying a sample of procedures for review, two criteria were considered very important. First, the procedures should be representative, or typical, of plant operating procedures in general. Second, the procedures should, to the greatest extent possible, be utilized at both boiling and pressurized water reactors in order to minimize the difficulty of drawing comparisons across plants.

Working closely with the peer review group and the NRC technical monitor, six procedures were identified as meeting these criteria. The procedures were intended to be representative of three different classes of operating procedures which are within the scope of this project: normal operating

BEST COPY AVAILABLE

procedures, normal operating procedures governing calculations, and abnormal operating procedures. The procedures are as follows:

Normal operating procedures:

Plant start-up to 15 percent power
Start-up of the condensate and feedwater system(s)

Normal operating calculation procedures:

Reactivity balance
Reactor coolant leak rate

Abnormal operating procedures:

Loss of condenser vacuum
Loss of component cooling.

C. Collecting the Procedures

All NRC licensees with at least one commercially operating plant were asked to provide current copies of the six procedures listed above. Plant managers were sent a letter requesting their assistance, a description of the project and planned review of procedures, and a postage-paid return envelope. On the basis of this one-time mailing to 56 sites (83 plants), a total of 154 procedures were returned by 31 sites (representing 46 plants). Copies of the letter and project description are printed on pages E-57 to E-58, below.

D. Reviewing the Procedures

Five project team members conducted the review and evaluation of procedures. All reviewers had prior experience in drafting procedure preparation guidelines, reviewing procedures, and/or developing the evaluation checklist. The evaluators pilot tested the rating forms individually on a small sample of procedures, and then discussed the ratings, evaluation criteria, and the rating forms to (a) insure a common basis of evaluation and (b) revise the rating forms as needed. Throughout the evaluation process, individual reviewers collaborated on questionable items or procedures.

As procedures were received from operating plants, all identifiers (plant name, utility name, etc.) were removed from the procedures. This minimized the effects of possible evaluator bias and assured the anonymity of the plants participating in the review. Evaluators were assigned procedures to review on the basis of the evaluator's availability. Each evaluator reviewed between 9 and 49 procedures. Each rated all of the procedures provided by a particular plant in order to facilitate overall judgments about the consistency in format across different types of procedures from a given plant.

E. Analyzing the Results of the Review

Analyses of the results of the review were designed to permit a description of the results and to draw conclusions about the usability of

BEST COPY AVAILABLE

operating procedures based on the particular information generated with the procedure rating form. All analyses were conducted using a Corona personal computer with an Omega cartridge disk subsystem and Statistical Package for the Social Sciences software.[1] Tables 1 through 34 present summaries of the ratings given procedures on each item of the procedure rating form. (Some of these data are also presented in Tables 4.3 and 4.4, Section 4 of this report.) Table 35 presents the reviewers' judgments of the consistency of the format used for procedures at plants, an item tapped by the plant Procedure Rating Form.

In addition to the descriptive and summary statistics presented in these tables, several comparisons were made among the procedures reviewed. No statistically significant differences were found between the means of the standardized overall rating scores[2] of the different types of procedures or different NRC regions.[3] A highly significant difference was found between the standardized overall ratings of procedures from BWRs and PWRs. The mean score of procedures from BWRs was significantly higher than were those from PWRs.[4] A number of factors could explain this difference. However, on the basis of this project, it is impossible to pinpoint the reason for this difference in overall ratings of procedures from different types of plants.

To check for a possible relationship between the number of pages or revisions and the standardized overall ratings of the procedure, correlations were computed for each. Table 36 presents the correlations between the overall ratings and the number of pages in each procedure as well as the correlations between the overall ratings and the number of revisions for each procedure. As can be seen by these correlations, there appears to be a positive relationship between the number of pages in a procedure and the overall ratings of the procedure, i.e., longer procedures have better ratings.

In addition, a principal-components factor analysis with a varimax rotation was conducted of all qualitative items on the rating form. Factor analysis is a technique to identify and sort clusters of intercorrelated items

---

[1]Norusis, Marisa J. SPSS/PC for the IBM PC/XT. Chicago: SPSS, Inc., 1984. See pp. B143-B153 for a discussion of analysis of variance and pp. B241-B263 for a discussion of factor analysis, techniques used in these analyses.

[2]Initial analyses of the results of the procedure evaluation revealed some differences between individual reviewers. To correct for these differences, each rater's quality judgments were normalized. All results discussed here reflect the corrected, "standardized" rating scores. (See Appendix E for tables summarizing the ratings on each item in the rating form.)

[3]One-way analysis of variance tests showed that for different types of procedures $F = .79$ and degrees of freedom = 5; for NRC regions $F = .63$, degrees of freedom = 4. Neither of these approach statistical significance.

[4]The results of the one-way analysis of variance were: $F = 12.97$, $df = 2$, $p < .001$.

BEST COPY AVAILABLE

from a larger set of items. In this case, factor analysis was used in order to identify, by examining correlations between items on the rating form, dimensions on which to evaluate other procedures. Table 37 presents the orthogonally rotated factor matrix resulting from this analysis.

The factor analysis of items rating the quality of procedures on the rating form revealed the existence of eight principle factors, or evaluative dimensions. These factors were:

1. The ease with which the procedure could be used. This dimension was based on the consistency and ease with which the procedure can be followed, the appropriate use of action verbs, the use of short concise procedural steps, and the provision of background and reference information where needed.

2. Where warnings and cautions are located and how they are identified.

3. Indicators to the operator that the objectives of the step have been completed. These included single indications as well as multiple indications. The quality of the table of contents also contributed to this factor.

4. Specificity within the procedure. This included items such as the degree to which the procedure specifically identifies the steps to be taken, the degree to which limits (i.e., temperature, number of turns, etc.) are expressed quantitatively, and the proper use of logic statements within the procedure.

5. Consistency in the use of terms and units throughout the procedure.

6. Clearly defined entry and exit conditions, including what should be done next.

7. Administrative and organizational steps taken to make the procedure easier to use. This includes items such as the quality of checklists and placekeeping aids, the quality and usability of graphs and figures, and the way in which the procedure is written for the use of both experienced and inexperienced operators.

8. Clearly defined purpose and objectives of the procedure.

BEST COPY AVAILABLE

Table 1A. Table of Contents Included (Item 1) by Procedure (N=154)

Procedure Type	Table of Contents Present	Absent
Start-up	12	17
Condensate and Feedwater Start-up	10	19
Reactivity Balance	2	19
Reactor Coolant Leak Calculation	3	21
Loss of Condenser Vacuum	3	20
Loss of Component Cooling	7	21
Total	37	117
	(24%)	(76%)

BEST COPY AVAILABLE

Table 1B. Usability of Table of Contents (Item 1) by Procedure (N=37)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	3	6	3
Condensate and Feedwater Start-up	3	3	4
Reactivity Balance	0	1	1
Reactor Coolant Leak Calculation	0	1	2
Loss of Condenser Vacuum	0	2	1
Loss of Component Cooling	1	5	1
Total	7	18	12
	(19%)	(49%)	(32%)

BEST COPY AVAILABLE

Table 2A. Statement of Objectives Included (Item 2) by Procedure (N=154)

Procedure Type	Statement of Objectives Present	Absent
Start-up	27	2
Condensate and Feedwater Start-up	22	7
Reactivity Balance	16	5
Reactor Coolant Leak Calculation	20	4
Loss of Condenser Vacuum	12	11
Loss of Component Cooling	12	16
Total	109	45
	(71%)	(29%)

BEST COPY AVAILABLE

Table 2B. Objectives Clearly Defined (Item 2) by Procedure (N=109)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	8	10	9
Condensate and Feedwater Start-up	8	7	7
Reactivity Balance	4	8	4
Reactor Coolant Leak Calculation	2	12	6
Loss of Condenser Vacuum	5	6	1
Loss of Component Cooling	3	4	5
Total	30	47	32
	(28%)	(43%)	(29%)

BEST COPY AVAILABLE

Table 3A. Page Layout Consistent (Item 3) by Procedure (N=154)

Procedure Type	Consistent Page Layout: Present	Consistent Page Layout: Absent
Start-up	29	0
Condensate and Feedwater Start-up	29	0
Reactivity Balance	21	0
Reactor Coolant Leak Calculation	24	0
Loss of Condenser Vacuum	23	0
Loss of Component Cooling	28	0
Total	154	0
	(100%)	(0%)

BEST COPY AVAILABLE

Table 3B. Usability of Page Layout (Item 3) by Procedure (N=154)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	6	18	5
Condensate and Feedwater Start-up	8	17	4
Reactivity Balance	12	9	0
Reactor Coolant Leak Calculation	9	11	4
Loss of Condenser Vacuum	7	11	5
Loss of Component Cooling	7	14	7
Total	49	80	25
	(32%)	(52%)	(16%)

BEST COPY AVAILABLE

Table 4. Sign-off or Approval Signature(s) Included (Item 4) by Procedure (N=153)

Procedure Type	Sign-off or Approval Signature	
	Present	Absent
Start-up	25	4
Condensate and Feedwater Start-up	24	5
Reactivity Balance	18	3
Reactor Coolant Leak Calculation	19	4
Loss of Condenser Vacuum	17	6
Loss of Component Cooling	23	5
Total	126	27
	(82%)	(18%)

BEST COPY AVAILABLE

Table 5. Procedure Name Appears on Every Page (Item 5) by Procedure (N=154)

Procedure Type	Procedure Name	
	Present	Absent
Start-up	7	22
Condensate and Feedwater Start-up	6	23
Reactivity Balance	3	18
Reactor Coolant Leak Calculation	2	22
Loss of Condenser Vacuum	7	16
Loss of Component Cooling	5	23
Total	30	124
	(19%)	(81%)

BEST COPY AVAILABLE

Table 6. Procedure Number Appears on Every Page (Item 6) by Procedure (N=154)

Procedure Type	Procedure Number	
	Present	Absent
Start-up	29	0
Condensate and Feedwater Start-up	29	0
Reactivity Balance	21	0
Reactor Coolant Leak Calculation	24	0
Loss of Condenser Vacuum	23	0
Loss of Component Cooling	27	1
Total	153	1
	(99%)	(1%)

BEST COPY AVAILABLE

Table 7. Revision Number Appears on Every Page (Item 7) by Procedure (N=153)

Procedure Type	Revision Number Present	Absent
Start-up	21	8
Condensate and Feedwater Start-up	21	8
Reactivity Balance	15	6
Reactor Coolant Leak Calculation	15	9
Loss of Condenser Vacuum	15	8
Loss of Component Cooling	18	9
Total	105	48
	(69%)	(31%)

BEST COPY AVAILABLE

Table 8. Date of Procedure Appears on Every Page (Item 8) by Procedure (N=154)

Procedure Type	Date of Procedure Present	Absent
Start-up	15	14
Condensate and Feedwater Start-up	11	18
Reactivity Balance	6	15
Reactor Coolant Leak Calculation	7	17
Loss of Condenser Vacuum	11	12
Loss of Component Cooling	13	15
Total	63	91
	(41%)	(59%)

BEST COPY AVAILABLE

Table 9. "Page -- of --" on Every Page (Item 9) by Procedure (N=154)

Procedure Type	"Page -- of --" Present	Absent
Start-up	18	11
Condensate and Feedwater Start-up	19	10
Reactivity Balance	13	8
Reactor Coolant Leak Calculation	13	11
Loss of Condenser Vacuum	16	7
Loss of Component Cooling	17	11
Total	96	58
	(62%)	(38%)

BEST COPY AVAILABLE

Table 10. The Most Recent Revisions to Procedure Are Identified or Highlighted (Item 10) by Procedure (N=153)

Procedure Type	Identification of Recent Revisions	
	Present	Absent
Start-up	9	20
Condensate and Feedwater Start-up	8	21
Reactivity Balance	6	15
Reactor Coolant Leak Calculation	9	15
Loss of Condenser Vacuum	7	16
Loss of Component Cooling	8	19
Total	47	106
	(31%)	(69%)

BEST COPY AVAILABLE

Table 11. Placekeeping Aids Appear Useful (Item 11) by Procedure (N=99)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	3	13	12
Condensate and Feedwater Start-up	3	7	10
Reactivity Balance	5	9	2
Reactor Coolant Leak Calculation	8	4	5
Loss of Condenser Vacuum	3	4	1
Loss of Component Cooling	4	6	0
Total	26	43	30
	(26%)	(43%)	(30%)

BEST COPY AVAILABLE

Table 12. Warnings and Cautions Properly Placed (Item 12) by Procedure (N=94)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	15	8	5
Condensate and Feedwater Start-up	9	9	6
Reactivity Balance	4	2	2
Reactor Coolant Leak Calculation	6	2	4
Loss of Condenser Vacuum	6	2	0
Loss of Component Cooling	7	4	3
Total	47	27	20
	(50%)	(29%)	(21%)

BEST COPY AVAILABLE

Table 13. Warnings and Cautions Are Clearly Identified (Item 13) by Procedure (N=92)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	16	7	5
Condensate and Feedwater Start-up	15	4	5
Reactivity Balance	5	1	1
Reactor Coolant Leak Calculation	6	3	2
Loss of Condenser Vacuum	6	1	0
Loss of Component Cooling	10	3	2
Total	58	19	16
	(63%)	(21%)	(15%)

BEST COPY AVAILABLE

Table 14. Figures, Tables, and Graphs Appear Usable (Item 14) by Procedure (N=68)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	7	9	1
Condensate and Feedwater Start-up	2	5	3
Reactivity Balance	8	6	2
Reactor Coolant Leak Calculation	8	7	1
Loss of Condenser Vacuum	2	1	1
Loss of Component Cooling	4	1	0
Total	31	29	8
	(46%)	(43%)	(12%)

BEST COPY AVAILABLE

Table 15. Procedures Contain Only One Action Verb Per Step (Item 15) by Procedure (N=153)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	12	7	10
Condensate and Feedwater Start-up	7	14	8
Reactivity Balance	7	10	3
Reactor Coolant Leak Calculation	10	11	3
Loss of Condenser Vacuum	2	16	5
Loss of Component Cooling	8	15	5
Total	46	73	34
	(30%)	(48%)	(22%)

BEST COPY AVAILABLE

Table 16. Instructions Are Written in Short, Identifiable Steps (Item 16) by Procedure (N=153)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	8	11	10
Condensate and Feedwater Start-up	5	14	10
Reactivity Balance	7	11	2
Reactor Coolant Leak Calculation	8	12	4
Loss of Condenser Vacuum	2	13	8
Loss of Component Cooling	6	15	7
Total	36	76	41
	(24%)	(50%)	(27%)

BEST COPY AVAILABLE

Table 17. Steps Specifically Identify the Action to Be Taken (Item 17) by Procedure (N=153)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	9	13	7
Condensate and Feedwater Start-up	9	12	8
Reactivity Balance	4	12	4
Reactor Coolant Leak Calculation	13	8	3
Loss of Condenser Vacuum	14	4	5
Loss of Component Cooling	18	7	3
Total	67	56	30
	(44%)	(37%)	(20%)

BEST COPY AVAILABLE

Table 18A. Limits Expressed Quantitatively (Item 18) by Procedure (N=153)

Procedure Type	Limits Expressed Quantitatively	
	Present	Absent
Start-up	28	1
Condensate and Feedwater Start-up	24	5
Reactivity Balance	19	2
Reactor Coolant Leak Calculation	19	4
Loss of Condenser Vacuum	18	5
Loss of Component Cooling	18	10
Total	126	27
	(82%)	(18%)

BEST COPY AVAILABLE

Table 18B. Usability of Quantitative Limits (Item 18) by Procedure (N=126)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	4	13	11
Condensate and Feedwater Start-up	4	13	7
Reactivity Balance	1	13	5
Reactor Coolant Leak Calculation	1	14	4
Loss of Condenser Vacuum	6	11	1
Loss of Component Cooling	3	14	1
Total	19	78	29
	(15%)	(62%)	(23%)

BEST COPY AVAILABLE

Table 19. Extent to Which Units Are Consistent Within Each Procedure (Item 19) by Procedure (N=147)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	3	17	9
Condensate and Feedwater Start-up	2	18	7
Reactivity Balance	2	12	7
Reactor Coolant Leak Calculation	2	15	4
Loss of Condenser Vacuum	2	16	4
Loss of Component Cooling	5	19	3
Total	16	97	34
	(11%)	(66%)	(23%)

BEST COPY AVAILABLE

Table 20A. Controls Identified Completely (Item 20) by Procedure (N=154)

Procedure Type	Controls Identified Completely	
	Present	Absent
Start-up	27	2
Condensate and Feedwater Start-up	29	0
Reactivity Balance	14	7
Reactor Coolant Leak Calculation	21	3
Loss of Condenser Vacuum	17	6
Loss of Component Cooling	26	2
Total	134	20
	(87%)	(13%)

BEST COPY AVAILABLE

Table 20B. Extent to Which Controls Are Identified Completely (Item 20) by Procedure (N=135)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	4	17	7
Condensate and Feedwater Start-up	4	10	15
Reactivity Balance	4	6	4
Reactor Coolant Leak Calculation	7	9	5
Loss of Condenser Vacuum	9	4	4
Loss of Component Cooling	14	9	3
Total	42	55	38
	(31%)	(41%)	(28%)

BEST COPY AVAILABLE

Table 21. Nomenclature Within Procedures Is Consistent (Item 21) by Procedure (N=153)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	1	20	8
Condensate and Feedwater Start-up	1	20	8
Reactivity Balance	0	17	4
Reactor Coolant Leak Calculation	2	19	3
Loss of Condenser Vacuum	0	19	3
Loss of Component Cooling	4	20	4
Total	8	115	30
	(5%)	(75%)	(20%)

BEST COPY AVAILABLE

Table 22. Logic Statements Used Properly (Item 22) by Procedure (N=143)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	10	12	3
Condensate and Feedwater Start-up	14	13	0
Reactivity Balance	9	9	2
Reactor Coolant Leak Calculation	12	12	0
Loss of Condenser Vacuum	9	12	1
Loss of Component Cooling	12	12	1
Total	66	70	7
	(46%)	(49%)	(5%)

BEST COPY AVAILABLE

Table 23A. Procedures Are Written at Two Levels, for Experienced and and Inexperienced Personnel (Item 23) by Procedure (N=153)

Procedure Type	Written at Two Levels: Present	Written at Two Levels: Absent
Start-up	3	26
Condensate and Feedwater Start-up	2	27
Reactivity Balance	1	20
Reactor Coolant Leak Calculation	1	22
Loss of Condenser Vacuum	1	22
Loss of Component Cooling	2	26
Total	10	143
	(7%)	(93%)

BEST COPY AVAILABLE

Table 23B. Usability of Procedures Written at Two Skill Levels (Item 23) by Procedure (N=10)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	0	2	1
Condensate and Feedwater Start-up	0	2	0
Reactivity Balance	1	0	0
Reactor Coolant Leak Calculation	1	0	0
Loss of Condenser Vacuum	0	0	1
Loss of Component Cooling	1	1	0
Total	3	5	2
	(30%)	(50%)	(20%)

BEST COPY AVAILABLE

Table 24A. Single Indicators of Achieved Objectives Included (Item 24) by Procedure (N=154)

Procedure Type	Single Indicators	
	Present	Absent
Start-up	28	1
Condensate and Feedwater Start-up	25	4
Reactivity Balance	10	11
Reactor Coolant Leak Calculation	17	7
Loss of Condenser Vacuum	11	12
Loss of Component Cooling	17	11
Total	108	46
	(70%)	(30%)

BEST COPY AVAILABLE

Table 24B. Usability of Single Indicators of Achieved Objectives (Item 24) by Procedure (N=108)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	6	20	2
Condensate and Feedwater Start-up	2	15	8
Reactivity Balance	0	9	1
Reactor Coolant Leak Calculation	1	13	3
Loss of Condenser Vacuum	1	10	0
Loss of Component Cooling	4	11	2
Total	14	78	16
	(13%)	(72%)	(15%)

BEST COPY AVAILABLE

Table 25A. Multiple Indicators of Achieved Objectives Included (Item 25) by Procedure (N=154)

Procedure Type	Multiple Indicators Present	Absent
Start-up	11	18
Condensate and Feedwater Start-up	9	20
Reactivity Balance	7	14
Reactor Coolant Leak Calculation	9	15
Loss of Condenser Vacuum	7	16
Loss of Component Cooling	9	19
Total	52	102
	(34%)	(66%)

BEST COPY AVAILABLE

Table 25B. Usability of Multiple Indicators of Achieved Objectives (Item 25) by Procedure (N=52)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	1	9	1
Condensate and Feedwater Start-up	0	5	4
Reactivity Balance	0	5	2
Reactor Coolant Leak Calculation	1	6	2
Loss of Condenser Vacuum	1	4	2
Loss of Component Cooling	2	5	2
Total	5	34	13
	(10%)	(65%)	(25%)

BEST COPY AVAILABLE

Table 26A. Entry Conditions Clearly Specified (Item 26) by Procedure (N=154)

Procedure Type	Entry Conditions Present	Absent
Start-up	29	0
Condensate and Feedwater Start-up	27	2
Reactivity Balance	18	3
Reactor Coolant Leak Calculation	22	2
Loss of Condenser Vacuum	22	1
Loss of Component Cooling	28	0
Total	146	8
	(95%)	(5%)

BEST COPY AVAILABLE

Table 26B. Clarity of Entry Conditions (Item 26) by Procedure (N=146)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	4	13	12
Condensate and Feedwater Start-up	6	14	7
Reactivity Balance	2	9	7
Reactor Coolant Leak Calculation	2	12	8
Loss of Condenser Vacuum	7	10	5
Loss of Component Cooling	6	20	2
Total	27	78	41
	(18%)	(53%)	(28%)

BEST COPY AVAILABLE

Table 27A. Exit Conditions Clearly Specified (Item 27) by Procedure (N=154)

Procedure Type	Exit Conditions	
	Present	Absent
Start-up	24	5
Condensate and Feedwater Start-up	21	8
Reactivity Balance	14	7
Reactor Coolant Leak Calculation	20	4
Loss of Condenser Vacuum	18	5
Loss of Component Cooling	22	6
Total	119	35
	(77%)	(23%)

BEST COPY AVAILABLE

Table 27B. Clarity of Exit Conditions (Item 27) by Procedure (N=119)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	7	11	6
Condensate and Feedwater Start-up	4	11	6
Reactivity Balance	4	8	2
Reactor Coolant Leak Calculation	4	13	3
Loss of Condenser Vacuum	7	7	4
Loss of Component Cooling	9	10	3
Total	35	60	24
	(29%)	(50%)	(20%)

BEST COPY AVAILABLE

Table 28. Completeness of References to Other Procedures (Item 28) by Procedure (N=146)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	8	17	4
Condensate and Feedwater Start-up	11	14	4
Reactivity Balance	8	9	1
Reactor Coolant Leak Calculation	7	11	2
Loss of Condenser Vacuum	11	10	2
Loss of Component Cooling	7	15	5
Total	52	76	18
	(36%)	(52%)	(12%)

BEST COPY AVAILABLE

Table 29. References to Other Procedures Include Specific Section or Step (Item 29) by Procedure (N=142)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	16	5	7
Condensate and Feedwater Start-up	20	6	3
Reactivity Balance	12	3	2
Reactor Coolant Leak Calculation	13	5	2
Loss of Condenser Vacuum	18	2	1
Loss of Component Cooling	23	4	0
Total	102	25	15
	(72%)	(18%)	(11%)

BEST COPY AVAILABLE

Table 30A. Subsequent Actions Clearly Identified (Item 30) by Procedure (N=151)

Procedure Type	Subsequent Actions	
	Present	Absent
Start-up	22	7
Condensate and Feedwater Start-up	14	14
Reactivity Balance	16	5
Reactor Coolant Leak Calculation	19	4
Loss of Condenser Vacuum	18	4
Loss of Component Cooling	19	9
Total	108	43
	(71%)	(28%)

BEST COPY AVAILABLE

Table 30B. Clarity of Subsequent Actions (Item 30) by Procedure (N=108)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	0	10	12
Condensate and Feedwater Start-up	1	10	3
Reactivity Balance	3	10	3
Reactor Coolant Leak Calculation	2	12	5
Loss of Condenser Vacuum	10	4	4
Loss of Component Cooling	5	9	5
Total	21	55	32
	(19%)	(51%)	(30%)

BEST COPY AVAILABLE

Table 31. Procedure Clearly Indicates When It Is Complete (Item 31) by Procedure (N=149)

Procedure Type	Number of Procedures Given Each Rating		
	Poor	Acceptable	Good
Start-up	7	12	9
Condensate and Feedwater Start-up	17	11	1
Reactivity Balance	4	13	4
Reactor Coolant Leak Calculation	4	14	4
Loss of Condenser Vacuum	16	4	2
Loss of Component Cooling	14	11	2
Total	62	65	22
	(42%)	(44%)	(15%)

BEST COPY AVAILABLE

Table 32. Sources Used as Background for Procedure Are Referenced (Item 32) by Procedure (N=154)

Procedure Type	Background Sources	
	Present	Absent
Start-up	18	11
Condensate and Feedwater Start-up	18	11
Reactivity Balance	14	7
Reactor Coolant Leak Calculation	19	5
Loss of Condenser Vacuum	5	18
Loss of Component Cooling	4	24
Total	78	76
	(51%)	(49%)

BEST COPY AVAIL

X32

Table 33. Sources for Action Instructions Are Referenced (Item 33) by Procedure (N=154)

Procedure Type	Action Sources	
	Present	Absent
Start-up	17	12
Condensate and Feedwater Start-up	10	19
Reactivity Balance	10	11
Reactor Coolant Leak Calculation	8	16
Loss of Condenser Vacuum	4	19
Loss of Component Cooling	7	21
Total	56	98
	(36%)	(64%)

BEST COPY AVAILABLE

Table 34. Overall Evaluation Scores (Item 34) by Procedure (N=154)

Procedure Type	Evaluation Score: Very Poor	Poor	Minimally Acceptable	Good	Very Good
NOPs:					
Start-up	1	6	12	8	2
Condensate and Feedwater Start-up	4	7	11	6	1
Calculation:					
Reactivity Balance	2	7	7	3	2
Reactor Coolant Leak	4	6	10	4	0
AOPs:					
Loss of Condenser Vacuum	10	7	4	1	1
Loss of Component Cooling	10	10	6	2	0
Total	31	43	50	24	6
	(20%)	(28%)	(33%)	(16%)	(4%)

BEST COPY AVAILABLE

Table 35. Consistency of Procedure Formats Within Plants

Consistency of Procedure Formats	Number of Plants	Percentage of Plants
Consistent across normal and abnormal procedures	13	42%
Consistent within both normal and abnormal procedures	13	42%
Inconsistent within and across types of procedures	5	16%
Total	31	100%

BEST COPY AVAILABLE

Table 36. Correlations of Overall Ratings of Procedures Reviewed by Number of Pages and Number of Revisions

Procedure	Correlation with Number of Pages in the Procedure	Correlation with Number of Revisions
Start-up	r=.23	r=.10
Condensate and Feedwater Start-up	r=.39*	r=.09
Reactivity Calculations	r=.45*	r=.05
Coolant Leak Rate Calculations	r=.01	r=.13
Loss of Condenser Vacuum	r=.44*	r=.21
Loss of Component Cooling	r=.12	r=.26

* $p < .05$.

BEST COPY AVAILABLE

Table 37. Factor Matrix: Item Variable Loadings on the Eight Principal Factors

Rating Item Number	Factor Loading							
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
1	.01760	-.14133	.59810	-.36333	.21123	.10558	.02694	-.18735
2	.10814	-.15096	.06319	.03295	-.02152	.07924	.05073	.76350
3	.53203	.23694	.04674	.04854	-.19495	.12202	.06625	.38063
11	.21418	.12437	.08753	.11314	-.02853	.19903	.71200	.14245
12	.14641	.76244	.16511	.09163	.12767	.15073	.15283	-.02208
13	.15422	.83194	.02842	.06560	.07748	.11829	.00165	-.08585
14	.06852	.37365	-.01555	.03915	.02025	-.23188	.61576	.21298
15	.83124	.19915	-.02293	.12421	.17012	-.05659	.06284	.08288
16	.85232	.10068	.06158	.10918	.16424	-.00777	.03675	-.01459
17	.30803	.04364	.12712	.65038	.20125	.20526	.05442	.07935
18	-.00425	.06163	-.06064	.69965	.18276	.07399	.16728	.08606
19	.12393	.06572	.08766	.41179	.65024	.04505	.01942	-.06454
20	-.08967	.30541	.05975	.36226	.38606	.05056	.06671	.38802
21	.17691	.11735	.07118	.01779	.78958	-.02216	.14080	.02615
22	.37682	.09409	.29069	.53857	-.21790	.07524	.12922	-.22120
23	.04369	-.19575	-.04147	.19370	.30364	.02726	.68961	-.20460
24	.06424	.20348	.67365	.23373	.13170	-.01125	.03656	.25082
25	-.10098	.15096	.75436	.10668	-.01001	.17353	.00639	.07123
26	.11161	-.06358	.29312	.01541	.18212	.43618	.11437	.28319
27	.24210	.12577	.27546	.05521	.35683	.37381	.06135	.35598
28	.49521	-.07655	-.17607	.03962	.08559	.19483	.18286	.04645
29	.33631	.15662	-.41910	.01696	.21223	.35356	.26853	.01484
30	-.02052	.02198	.09133	.10697	-.07123	.76724	.07158	.07239
31	.09347	.33825	-.00728	.11954	.01114	.68043	-.11233	-.04236
Eigen-value	5.046	2.085	1.611	1.430	1.325	1.197	1.130	1.061

BEST COPY AVAILABLE

OPERATING PROCEDURE RATING FORM

PROCEDURE NAME _____ REVISION NO. _____ TOTAL NO. OF PAGES _____ PROCEDURE TYPE ☐ Normal ☐ Abnormal ☐ Emergency ☐ Don't Know

PLANT NUMBER _____ NRC REGION _____ PLANT TYPE ☐ BWR ☐ PWR ☐ Other RATER ID _____

Note: Blank = Not Applicable

	Present	Absent	Quality		
FORMAT	1	0	-	0	+
1. Table of Contents included					
2. Objectives clearly defined					
3. Page layout (format) consistent (easy to follow)					
4. Sign-off present					
5. Procedure name on every page					
6. Procedure number on every page					
7. Revision number appears on each page					
8. Date appears on each page					
9. "Page _____ of _____" on every page					
10. Most recent revisions are marked					
11. Placekeeping aids (e.g., checklist) appear useful					
12. Warnings and Cautions properly placed					
13. Warnings and Cautions clearly identified					
14. Figures, Tables, and Graphs appear usable					
STYLE OF EXPRESSION AND PRESENTATION					
15. Action instructions in procedure contain only one action (verb) per step					
16. Instructions are written in short, concise, identifiable steps (as opposed to multi-step paragraphs)					
17. Steps specifically identify the action to be taken					

BEST COPY AVAILABLE

PROCEDURE NAME _____ PLANT NUMBER _____ RATER ID _____

STYLE OF EXPRESSION AND PRESENTATION (cont.)	Present 1	Absent 0	Quality -	Quality 0	Quality +
18. Steps express limits quantitatively (e.g., "2 turns," "100 psig," etc.)					
19. Units consistent within procedure (steps, graphs, etc., consistent with text)					
20. Indicators, controls, and/or equipment identified completely					
21. Nomenclature within the procedures is consistent					
22. Logic statements used properly (see CR 1977)					
23. Procedures are written at two levels, for experienced and inexperienced operations personnel					
CONTENT					
24. Single indicators of achieved objectives included					
25. Multiple indicators of achieved objectives included					
26. Criteria for using this procedure are clearly specified (Entry Conditions)					
27. Criteria for going to another procedure are clearly specified (Exit Conditions)					
28. Instructions contain complete reference(s) to other procedures					
29. References to other procedures specify specific section or step of referenced procedure					
30. Subsequent actions clearly identified (e.g., specify follow-on procedure, identify person to be notified, etc.)					
31. Procedure clearly indicates when it is complete					
32. Source documents, tech specs, etc., used as background for procedure are referenced					
33. Source documents, tech specs, etc., for action instructions are referenced in the procedure					
34. Rater's overall judgment of procedure: 1=very poor; 2=poor; 3=minimally acceptable; 4=good; 5=very good	_____				

BEST COPY AVAILABLE

PLANT PROCEDURE RATING FORM

PLANT NUMBER _____ RATER ID _____ NUMBER OF PROCEDURES REVIEWED _____

Procedures Reviewed (circle one for each procedure):

Yes	No	PLANT START
Yes	No	COND & FEED
Yes	No	R BAL
Yes	No	RC LEAK
Yes	No	L/COND VAC
Yes	No	L/COMP COOL

Format Is Consistent (check one):

|__|$_1$ a. across procedures

|__|$_2$ b. within abnormal procedures only

|__|$_3$ c. within normal procedures only

|__|$_4$ d. within both (but not across normal and abnormal) procedures

|__|$_5$ e. not at all/very little

BEST COPY AVAILABLE

Battelle
Seattle Research Center
4000 N.E. 41st Street
P.O. Box C-5395
Seattle, Washington 98105
Telephone (206) 525-3130
Cable BATSEA

Date: March 29, 1985

To: Plant Managers, Operating Nuclear Power Plants

From: Michael H. Morgenstern Mike
Operating Procedures Project Manager

Subject: Request for Selected Operating Procedures

The Pacific Northwest Laboratory and Battelle in Seattle are assisting the U.S. Nuclear Regulatory Commission Division of Human Factors Safety in its project to assess and upgrade operating procedures in nuclear power plants. For your information, a brief description of the Operating Procedures Project is enclosed. As part of Task 3 of this project, Battelle staff members are reviewing samples of plant operating procedures.

We would very much appreciate the opportunity to review several procedures currently in use at your plant. In particular, we are interested in reviewing the following six procedures:

1. Plant Heatup and Startup (i.e., from initial criticality to 15% power; from manual to automatic control of feedwater)
2. Startup Condensate and Feedwater
3. Reactivity Balance
4. Reactor Coolant Leak Rate Calculation
5. Loss of Condenser Vacuum
6. Loss of Component Cooling

Assisting us in this way is voluntary, and the identity of all plants participating in this procedure review will be kept confidential. No individual plants will be identified during review of the procedures or in any reports of this effort. This information collection has been approved under OMB Clearance Number 3150-0065 which expires September, 1985.

Please send copies of these procedures in the enclosed return envelope.

Should you have any questions about this project, please do not hesitate to contact Dr. Michael Goodman at the NRC, (301) 492-4583, or Mr. Michael Morgenstern at Battelle, (206) 525-3130, ext. 268.

Thank you very much for your time and assistance.

MM:cs
Enclosure

BEST COPY AVAILABLE

141

PROJECT FOR ASSESSING AND UPGRADING OPERATING PROCEDURES IN NUCLEAR POWER PLANTS: OVERVIEW AND SUMMARY

The purpose of this project is to assess current practices and problems related to operating procedures and, if necessary, to recommend an implementation plan for upgrading operating procedures. To this end, the following five project tasks have been designed.

Task 1. Define the Scope of "Operating Procedures" and Refine Project Focus

This task involved defining those plant procedures that should be classified as "operating procedures" and determining the range of procedures to be addressed by this effort. (This task is complete.)

Task 2. Review Existing Data Bases

This task involved identifying and reviewing existing studies and related data on current nuclear power plant operating procedures. Sources of information included the NRC, industry-sponsored groups, LERs, and the 766 data base. (This task is complete.)

Task 3. Define Current Industry Practices and Problems

This task involves site visits to one or two operating plants in each NRC region in order to gather information on actual experiences and practices concerning the development, control, use, and revision of operating procedures. In addition, this task involves desk-top review of several written operating procedures in use at operating nuclear power plants throughout the country. (The site visits have been completed.)

Task 4. Select and Convene Project Peer Review Group

This task involves the selection of a peer review group of experts on operating procedures representing experience in both nuclear and non-nuclear settings. The purpose of the review group is to advise the project team and the NRC Project Monitor on the course of the project, to comment on project findings, and to suggest alternative approaches/conclusions for the project to follow. (The review group has been formed and two peer review group meetings have been held.)

Task 5. Prepare Report and Develop Program Plan for Upgrading Operating Procedures

This task involves the preparation of a project report that summarizes the findings of Tasks 1 through 4, identifies nuclear power plant operating procedures problems, assesses the adequacy of current operating procedures practices and existing industry standards, and presents a plan for upgrading operating procedures. (The report will be completed during Summer 1985.)

BEST COPY AVAILABLE

APPENDIX F

SITE VISIT METHODOLOGY AND PROTOCOL

BEST COPY AVAILABLE

APPENDIX F

SITE VISIT METHODOLOGY AND PROTOCOL

Site Selection. The sites visited were selected to capture a range of experience in commercial operations. Experience was defined in terms of the number of plants operated by a utility or the number of years the utility had at least one plant in commercial operations. In addition, variations in operating experience were expected between the five NRC regions. Therefore, with the exception of Region 5 (where so few plants were operating), experienced and inexperienced utilities in each NRC region were identified and the plant with the longest or shortest history of operations, as appropriate, was selected to contact.

Management personnel at each plant were contacted with a letter that described the specific purposes of the visit and the topics to be discussed. An enclosure provided a brief summary of the P-2 project as a whole. Management personnel were also telephoned to discuss the site visit, to establish a date for the visit, and to identify individuals to be interviewed.

Seven out of the nine plants originally identified agreed to participate. One of those that declined was in the midst of an NRC inspection and the other did not give a specific reason for choosing not to participate. To replace these two plants, the next most experienced and inexperienced plants within the relevant NRC regions were contacted.

Interview Protocol. The interview protocol developed to guide discussions with plant personnel included the following topics: methods for developing, distributing, using, and revising operating procedures as well as methods for managing interfaces between procedures. Additional interview topics, such as the relationship between training and procedures, were suggested by peer review group members at the first review group meeting. The complete interview follows this discussion.

Site Visit Procedures. As noted above, the organizational roles and job titles of the individuals interviewed varied from plant to plant because of the diversity of the organizational structures among the plants and because some target individuals were unavailable for interviews (e.g., attending off-site training sessions, on vacation). In general, project staff attempted to interview persons who were responsible for preparing procedures, senior operations personnel, operator training personnel, and reactor operators during control room walk-throughs.

The site visits were conducted by teams of two experienced interviewers. To enhance the probability of frank responses on the part of interviewees, project staff attempted to interview the plant personnel individually. (For this reason, comments cited in the report are not linked to identified persons or plants.) Guarantees of anonymity were given to participants. Individual interviews also allowed the interviewers to ask the same question of individuals at different levels of responsibility within the organization to obtain their different

BEST COPY AVAILABLE

perspectives on the topics. In addition to the formal interviews, project team members toured the control room at five of the plants visited. During the control room walk-throughs, project staff spoke with operators on duty and observed where operating procedures were kept and how they were bound and indexed.

BEST COPY AVAILABLE

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1 REPORT NUMBER (Assigned by TIDC and Vol. No., if any)
NUREG/CR-3968
PNL-5648
BHARC-400/85/017

2 TITLE AND SUBTITLE
Study of Operating Procedures in Nuclear Power Plants: Practices and Problems

3 LEAVE BLANK

4 DATE REPORT COMPLETED
MONTH: November YEAR: 1986

5 AUTHOR(S)
M.H. Morgenstern, V.E. Barnes, M.V. McGuire, L.R. Radford, W.A. Wheeler

6 DATE REPORT ISSUED
MONTH: February YEAR: 1987

7 PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Battelle Human Affairs Research Centers
4000 N.E. 41st Street
Seattle, WA 98105
Pacific Northwest Laboratory
Richland, WA 99352

8 PROJECT/TASK/WORK UNIT NUMBER

9 FIN OR GRANT NUMBER
B2360

10 SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Division of Human Factors Technology
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

11a TYPE OF REPORT
Technical

b PERIOD COVERED (Inclusive dates)
1/83 - 10/85

12 SUPPLEMENTARY NOTES

13 ABSTRACT (200 words or less)

This report describes the project activities, findings, and recommendations of a project entitled "Program Plan for Assessing and Upgrading Operating Procedures for Nuclear Power Plants." The project was performed by the Pacific Northwest Laboratory and Battelle Human Affairs Research Centers for the Division of Human Factors Technology, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (NRC).

The project team analyzed and evaluated samples of normal and abnormal operating procedures from 31 commercial nuclear power plants operating in the United States. The project team also visited nine nuclear power plants in the United States to obtain information on the development, use, and control of operating procedures. A peer review group was convened to advise the project team on the conduct of the project and to review and comment on the project report.

The report contains findings on the usability of operating procedures and on practices concerning the development, use, and control of operating procedures in nuclear power plants. The report includes recommendations to the NRC on the need to upgrade the quality of operating procedures. The report also discusses an approach to a program plan to assess and upgrade operating procedures.

14 DOCUMENT ANALYSIS - a KEYWORDS/DESCRIPTORS

Procedures
Operating procedures
Nuclear power plants
Human factors
Procedure usability checklist

b IDENTIFIERS/OPEN ENDED TERMS

15 AVAILABILITY STATEMENT
Unlimited

16 SECURITY CLASSIFICATION
(This page) Unclassified
(This report) Unclassified

17 NUMBER OF PAGES

18 PRICE

146

BEST COPY AVAILABLE